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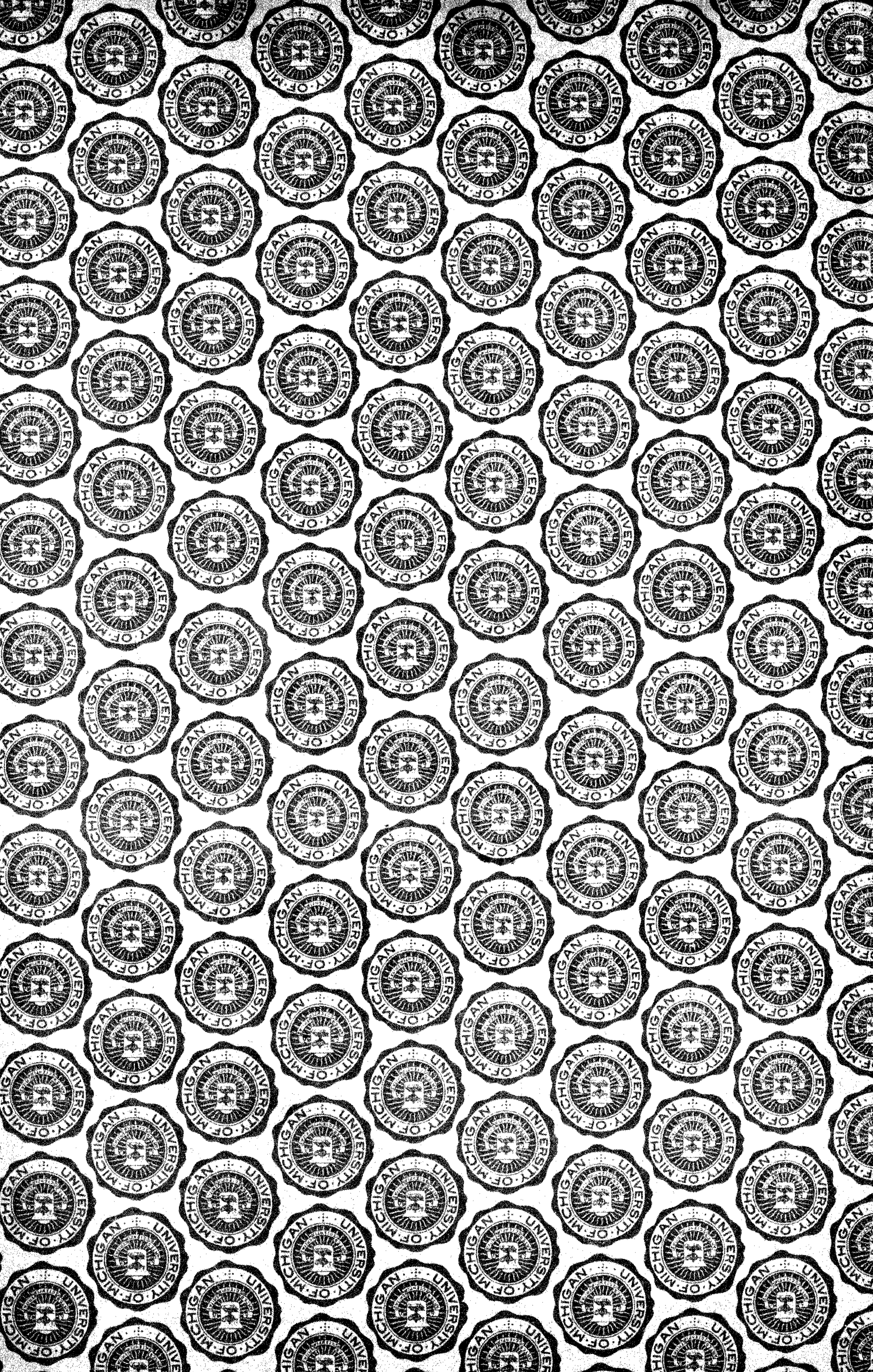

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WITH 159 PLATES AND 32 TEXT FIGURES

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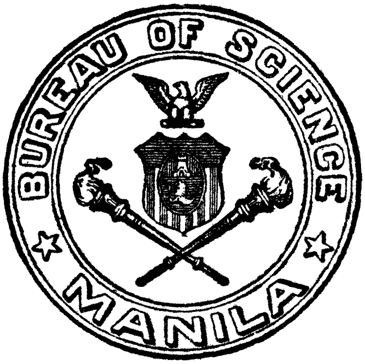

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THE PHILIPPINE
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VOL. 49 SEPTEMBER, 1932 No. 1

EQUINE OSTEOMALACIA [1]

By J. H. KINTNER and R. L. HOLT

Of the United States Army Medical Department Research Board
Bureau of Science, Manila

TWENTY-FOUR PLATES AND SIXTEEN TEXT FIGURES

INTRODUCTION

The prevalence of osteomalacia among animals in the Philippine Islands, its enormous economic importance both to the United States Army and civilians, and the wealth of material found in the Philippines, prompted the Medical Department Research Board to undertake an extensive investigation of this condition. The United States Army in the Philippines has been hampered seriously by the prevalence of this disease among its animals and the situation is but little less serious with regard to other locally owned animals, particularly imported breeding stock.

A critical review of the literature pertaining to osteomalacia, of both animals and humans, indicates that considerable confusion exists regarding this condition. The efforts of the board in the present investigation have been directed toward practically all phases of the disease as it affects the equine species, and it is hoped that much of the existing confusion will be lessened as a result of this work.

Various terms such as osteomalacia, osteoporosis, osteitis fibrosa, big head, millers' disease, bran disease, cachexia osseus, halisteresis ostium, osteopsathyrosis, rarefying osteitis, osteitis deformans, osteitis fibrosystica, osteodystrophia deformans, mol-

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[1] Received for publication January 17, 1932.

litis ossium, fragilitas ossium, etc., have been applied to this disorder by writers on the subject. Most of the terms used refer to a single predominating manifestation presented during the course of the disease and are not universal in their application. Of the many designations applied to this diseased condition in horses, the terms osteomalacia and osteoporosis are used most frequently. Some writers claim that osteomalacia and osteoporosis of equines are separate and distinct entities, others say that they are closely related conditions, while still others state that the conditions are identical. Mohler(1) claims that osteoporosis is a complete entity entirely independent of osteomalacia, citing the fact that osteomalacia occurs in range cattle in the southwestern part of the United States while osteoporosis in horses on the same range has not been noted. Further, he states that osteomalacia of cattle responds to treatment while osteoporosis of horses does not and that osteomalacia occurs in animals that graze on worn-out soil deficient in lime salts while osteoporosis may occur in animals that graze on rich fertile soil. Robertson(2) states that osteoporosis and osteomalacia are totally different diseases; different in cause, nature, treatment, and post-mortem lesions. He claims that the cause of osteomalacia is defective nutrition while osteoporosis is not induced in this manner. Further, that osteoporosis attacks only the Equidæ while osteomalacia may affect all domestic species. Forbes(3) states that osteoporosis appears to be distinct from osteomalacia in that the former disease does not respond to treatment with calcium phosphate and its etiology is unknown. This writer quotes D. Hutcheon, chief veterinary surgeon, Cape of Good Hope, who attempts to differentiate the two conditions on a pathological basis. Marek(4) claims that in osteoporosis there is an absence of osteoid tissue and that the two conditions are differentiated by the pathogenesis and the histological picture. Further, he states that osteoporosis may occur concurrently with osteomalacia. As opposed to these views, many investigators say that the conditions are identical or are related so closely that they should be considered as being the same disease. Friedberger and Frohner(5) in discussing osteoporosis state that the condition is related to osteomalacia and should not be considered a distinct disease. Winslow(6) recognizes the confusion that exists in designating the disease and prefers the term osteomalacia, stating that this term properly includes the various pathological conditions to which numerous names have been given. Law(7) states that osteoporosis is a form of osteomalacia occurring in horses. White(8) in his text on veterinary medicine discusses the two conditions under the same heading. Bordeaux(9) considers osteoporosis and osteomalacia of equines identical and prefers the latter term. Sturgess,(10) in a recent investigation of the condition in Ceylon, states that the term osteoporosis is not an exact description of the pathological changes occurring in the disease, but retains the term as it is the name with which horse owners in Ceylon are familiar. Miller(11) states that certain authorities claim that osteoporosis is associated with osteomalacia and may be a form of the same disease.

That the specific pathological process recognized as osteoporosis, abnormal porosity or rarefaction of bone, occurs in the condition under investigation is admitted by practically all investigators. Certain other pathological processes are usually present so that the complete micro- and macropathological picture is more than a simple osteoporosis. The writers, therefore, have used the term osteomalacia, as it includes the several pathological conditions present during the course of the disease and is based upon certain specific histological findings.

DEFINITION, HISTORY, AND OCCURRENCE

Definition.—Osteomalacia of animals is a disturbance of the mineral metabolism of the bones, possibly inflammatory in nature, wherein preëxisting bone is removed and replaced in part by osteoid tissue. Osteoporosis or rarefaction occurs concurrently with the condition. The disease is usually chronic but may be acute or subacute and usually involves all of the bones of the body.

History and occurrence.—Osteomalacia is one of the oldest diseases known and, according to Friedberger and Frohner,(5) was described accurately by Vegetius in the fourth century. Extensive outbreaks of the disease among animals are reported from Germany as early as 1778.(12) According to McCrudden,(13) Chossot (1842) was the first to produce artificial osteomalacia, which he accomplished by feeding pigeons a diet poor in calcium salts.

The disease has been reported in the following countries, some of which have had extensive outbreaks: Belgium, Germany, France, and Austria;(12) England, Scotland, Russia, and South Africa;(2) Hawaii;(14) parts of the United States and the Philippine Islands;(4) the Sandwich Islands;(15) the Transvaal;(16) New South Wales and India;(17) Uruguay;(18) and the Belgian Congo.(19) Per Tuf(20) reports that in Norway, where it has now lost much of its importance, severe outbreaks affecting cattle and horses occurred in 1860, in 1869 (over 2,000 cases), in 1876–77 (over 3,000 cases) and extensive outbreaks in 1904, 1905, 1911, and 1912. An epizoötic of the disease occurred in Switzerland in 1919.(21) Sturgess(10) states that in Colombo, Ceylon, at least 10 per cent of the horses are affected in varying degrees. The condition occurs in Brazil where it is known as "cara inchada."(22) It occurs enzoötically in certain regions of the United States, especially in New Jersey and the Mississippi Valley.(7) It is common in certain parts of the Philippine Archipelago.

While cattle, particularly dairy cows, are affected most frequently, horses, mules, asses, goats, dogs, sheep, and pigs are susceptible to the disease. Blair and Brooks(23) state that it is common among primates at zoölogical gardens, where it is known as "cage paralysis." Fox,(24) White,(25) and others report its presence among captive wild animals and birds. Law(7) reports that it is particularly common among Shetland ponies, while asses and mules habitually escape the disease.

Osteomalacia appears to be enzoötic in character. Many severe outbreaks are reported as having appeared after prolonged droughts. Some writers attach particular importance to the mineral nature of the soil, reporting either calcium or phosphate deficiency in affected areas. Mohler,(1) however, states that equine osteoporosis is found in limestone sections of the United States. In Ceylon, Sturgess(10) reports that there is very little difference in the incidence from year to year and that the disease is not seasonal.

Osteomalacia of humans has been reported from practically all civilized countries, and many extensive investigations have been carried out. A critical review and an able discussion of the literature on the subject have been published recently by Hess.(26)

SIMILAR DISEASES

Similar diseases.—Diseases of disturbed mineral metabolism have attracted considerable interest for many years. Due to recent advances in biological chemistry, in the knowledge regarding the physiological action of several of the glands with internal secretions, to the discovery of the vitamins, to the ability to produce several diseases of this character in experimental animals, and to the indicated significance in nutrition of several of the chemical elements, enormous quantities of interesting data have been published regarding mineral metabolism and diseases concerned therewith. A full discussion of all conditions related to osteomalacia is not contemplated, therefore, in the present paper. While the recent advances in the knowledge of mineral metabolism of animals have been exceedingly rapid and fruitful, the complex metabolic processes involved are not understood fully and it is impossible, therefore, to correlate properly the anatomical and physiological differences between the various species.

Rickets.—Until comparatively recent years considerable controversy existed concerning the relationship of rickets and osteomalacia. Hess(26) and others state that Virchow in 1853 advanced the theory that rickets and osteomalacia are different diseases, stating that in the latter disease there is absorption while in the former nothing essential is absorbed. Many of the early investigators believed in Virchow's theory. In 1885, Pommer demonstrated that bone is not a fixed tissue but is subject to changes throughout life. Pommer also claimed that in both rickets and osteomalacia the lessions are due, not to an increased absorption but to a decreased calcification.(26) Von Recklinghausen, as quoted by Hess, believed that both rickets and osteomalacia were associated with dissolution of bone, halisteresis, while Schmorl and Looser maintain that these diseases are due to failure of calcification and not to halisteresis. Wells(27) states that in rickets there is failure of the osteoid tissue to calcify while in osteomalacia absorption of calcified tissue takes place. Law(7) believes that in rickets the young bone is attacked at the seat of growth and under the periosteum while in osteoporosis (osteomalacia of the horse) the process attacks mature bone in its interior, producing a thinning of the walls of its vascular canals, cancellar cavities, and increasing the fibrocellular contents. Further, he states that the bony enlargements in rickets are due to deposition on the bone surface, while in osteomalacia expansion takes place from within. More-recent observers, however, are agreed that in rickets and osteomalacia the essential abnormality is a deficient calcification of the osteoid tissue and that the latter condition is really a manifestation of rickets in adult life. Steenbock and Hart(28) state that rickets, osteoporosis, and osteomalacia are all characterized by impoverishment of the bones in inorganic substances. Hess(26) believes that there is no essential difference between rickets and osteomalacia and that the difference in the pathological lesion between the two conditions is quantitative. Friedberger and Frohner(5) state that the two diseases are related and the differences in the pathological changes of the bone are due to age differences. Marek(4) agrees with Friedberger and Frohner and states that the difference is caused solely by the age of the diseased animal; he states further, that both diseases are identical in their nature, and the condition may be present in the same animal before it reaches maturity. Hutyra and Marek(12) believe that, while rickets and osteomalacia have much in common and that their anatomical and histological differences are due largely to the differences in ages of affected animals, the two conditions should be separated clinically and anatomically because of the age differences and the occasional etiological differences. Van Saceghem(19) contends that rickets, osteomalacia, and osteoporosis arise from identical causes and suggests the term "osseous cachexia" for the three diseases.

Equine osteoporosis.—The relationship of the so-called equine osteoporosis to osteomalacia has been considered in the introduction to this report. It is believed that the term osteoporosis should be used exclusively as a descriptive term of a specific pathological process (porosity or rarefaction of bone) and not as a disease entity.

Senile osteoporosis.—Senile osteoporosis, sometimes called senile osteomalacia, is a normal physiological process seen in the aged and causes atrophy and increased fragility of the bones without marked deformity. Senile osteoporosis differs chiefly in that no new osteoid tissue is formed.(27) This process may lead to such rarefaction that fractures are common.(29)

Styfsiekte.—This disease occurs among cattle of South Africa and is now recognized as a disease of disturbed mineral metabolism closely related to osteomalacia. Theiler, Green, and du Toit,(30) Malan, Green, and du Toit(31) and others have conducted extensive investigations of this condition. Hunter(32) in reviewing work on calcium and phosphorus metabolism states that styfsiekte is rickets, or osteomalacia, of a low phosphorus type.

Kennel lameness.—Brimhall and Hardenbergh(33) and Hardenbergh(34) report an outbreak of "rheumatism," or "kennel lameness," among mature dogs in which there was softening and deforming of certain bone structures approximating osteomalacia. In the latter report the writer considers the disease to be a type of osteomalacia.

Other diseases of bones.—The relationship of various exostoses commonly seen in horses as spavins, ringbones, and other bone diseases is unknown. Law(7) states that W. L. Williams noticed that for years after outbreaks of equine osteomalacia on two farms in central Illinois there was an unusual prevalence of spavins, ringbones, and other bone diseases. In connection with work on osteomalacia and rickets at the New York State Veterinary College(35) it was found that spavins and ringbones responded to treatment for osteomalacia and rickets.

It has been noted in the present investigation that exostoses of various types as well as numerous skin affections are associated commonly with osteomalacia of Army animals in the Philippine Islands.

ECONOMIC IMPORTANCE

Economic importance.—That such a disease of animals as osteomalacia is of tremendous economic importance needs no proof. The value of animals lost or incapacitated for work during long periods as a result of the disease cannot be estimated, but the loss is high. The United States Army in the Philippine Islands has been hampered seriously by the prevalence of this disease among its animals and the condition has led to a recommendation by at least one high Army commander that all units be motorized unless animals are indispensable. The situation is but little less serious with regard to native animals and animals imported by the Government of the Philippine Islands in its attempt to improve the quality of native stock by the use of pure-bred stallions. At the Trinidad Stock Farm of the Insular Government the condition was so serious that abandonment of the farm as a breeding station for horses was necessary.

The many reports of the presence of osteomalacia among animals of other countries prove it is a disease of prime importance in several of them.

PRESENT INVESTIGATION

GENERAL

Animals.—The present study of equine osteomalacia was begun in May, 1930, continued uninterruptedly for a period of approximately eighteen months, and was confined almost exclusively to United States Army animals in the Philippine Islands. During the period of investigation the Army animal strength of the Philippines was about 3,000 head, approximately 40 per cent of which were horses and 60 per cent mules. All of these animals, with the exception of a few that were foaled here from Army mares, were imported from the United States at various times during the past twenty years. Their source in the United States was largely the midwestern and southwestern sections of the country. From time to time as replacements are required, animals are shipped by Army transport to Manila.

Army animals in the Philippines are maintained at several Army posts, the largest group being stationed at Fort Stotsenburg, Pampanga (approximately 2,000 in number) and Fort William McKinley, Rizal (approximately 700). Smaller groups of from 20 to 100 are stationed at the Post of Manila (Manila), Camp Nichols (Rizal), Fort Mills (Corregidor), Camp John Hay (Mountain), and Zamboanga (Mindanao).

Animal management.—At large posts, namely Fort Stotsenburg, Fort William McKinley, and the Post of Manila, a veterinary service, including resident veterinary officers, supervises the animal management and provides care and treatment for all sick and wounded animals. The veterinary service at the smaller posts is provided by frequent visits of a veterinary officer. The system of veterinary service at the larger stations provides for frequent physical examination of all animals and a complete system of records of all animals unable to do full military duty. A definite means of identification of individual animals is provided for by the Preston Brand System, in which each animal is indelibly branded on the left side of the neck at time of entry into service. With this system of veterinary service, together with the recording of all disabilities of individual, definitely identified animals throughout their Army service, it has been possible to obtain valuable data.

The ages of Army animals in the Philippine Islands range from 4 years to approximately 30 years, the majority falling in the age group 10 to 16 years. Replacement animals coming to the Philippines vary in age from 4 to 7 years. It is estimated that the military life of a horse is about twelve years and that of a mule about fourteen years.

Forage and water.—In the early days of occupation in the Philippines, some of the animals were rationed entirely on native forage because sufficient American feed was not available.

The majority were fed imported forage. The ration for native ponies used by the Army in 1899 consisted of rough rice, tikitiki, molasses, and green grass. About 1907, with the idea of utilizing native forage as an economic substitute for a portion of the imported feed for American horses, and in order to make the Philippine Islands more self-sustaining, investigative work was started by Army authorities in coöperation with the Bureau of Agriculture of the Insular Government on the possibility of substituting native for imported feeds. Tests of various crops suitable for hay and green forage were conducted at different points throughout the Islands, but no definite conclusions were drawn.

In 1910, the Secretary of War appointed a board, members of which were civilians and military officers interested in the forage question in the Philippine Islands. The United States Department of Agriculture detailed a special representative to coöperate with this board. During the period September, 1910, to May, 1911, this board conducted about twenty-five feeding tests, using native and various combinations of native and American forage. Several rations were reported as being satisfactory, but the amount of suitable native products was insufficient to meet the demands of the Army. This board reported that native cracked corn and native palay (rough rice) could be fed in lieu of a portion of the imported oats and that native green grass could be substituted for a portion of the imported hay allowance.

For a year or two after the tests conducted by the forage board, attempts to obtain local hay met with some success at the different posts. At most places, however, there was an insufficient quantity available and necessary steps were not taken to increase the production. As a consequence the roughage component of the ration soon reverted to American hay. The feeding of approximately 11 pounds of native green grass in lieu of one-third of the hay allowance was in effect at this time.

The development of the present forage ration was started in 1922 when a board of Army officers was appointed to investigate the suitability of copra meal, a by-product in the coconut industry, as an article of food for animals. At this time the Army ration consisted of American oats, American grain hay, and native green grass. After numerous feeding experiments the board reported that a ration composed of one-third American oats, one-third copra meal, and one-third binilid or palay was considered satisfactory and this was adopted for the concentrate portion of the ration for Army animals.

In 1923 another forage board of Army officers was appointed and a careful investigation was made of the local forage situation. This board recommended a continuation of the grain ration of one-third oats, one-third copra meal, and one-third palay, and, further, that native rice hay be substituted for one-half of the American-hay allowance. Some time elapsed after the adoption of this ration before production of local forage permitted its general use. In the early experiments with rice hay, considerable difficulty was experienced in obtaining a product that was harvested at the proper stage of maturity and was well cured. This difficulty has been overcome to a great extent by requiring that the hay be cut while in the "milk stage" and the product, as now used, offers a fairly satisfactory substitute for a portion of the hay allowance.

With minor changes only, the following ration and allowance were in effect from 1923 to June, 1931:

TABLE 1.—*Forage for public animals.*

Animal.	Type.	American grain hay.	Native rice hay.	Native green forage.	Oats.	Native crushed palay.	Native copra meal.	Total. grain.
Horse	1,150 lbs. and over	5	5	12½	4	4	4	12
Do	900 to 1,150 lbs.	4½	4½	12½	3	3	3	9
Do	Under 900 lbs.	4½	4½	12½	2⅓	2⅓	2⅓	7
Mule	Draft	4½	4½	12½	2⅔	2⅔	2⅔	8
Do	Pack and saddle	4½	4½	12½	2⅓	2⅓	2⅓	7

The allowances in Table 1 represent the ration for animals doing garrison duty, practice marches, maneuvers, or field service of three days or less duration. The daily allowance of salt is 0.8 ounces per animal. For idle animals or those doing a small amount of light work, the concentrates of the ration are reduced 50 per cent. Grazing of animals is required whenever practicable. All forage is subjected to a critical inspection for sanitary condition and quality at the time of purchase.

During the fiscal year 1925 when the average daily strength was 4,000 animals the estimated savings that resulted from the partial substitution of native products for imported forage, was approximately 75,000 dollars. Due to the marked advance in the price of American farm products during the fiscal year 1926, the estimated savings by employing partial substitution of native products was approximately 200,000 dollars. Based upon the prices of forage and the average animal strength for the fiscal year 1930, a saving of approximately 87,700 dollars resulted from the utilization of native products.

In view of the savings effected by the use of native products, and the economic and informatory benefit derived by the civilian agricultural and livestock interests, one of the chief factors considered in the present investigation was the use of as large a proportion of Philippine products as was consistent with favorable results.

Drinking water for animals is secured from artesian wells at all posts except Fort Stotsenburg and Post of Manila. At the former post it is secured from Bamban River and Tipley Creek, while the city water supply of Manila is utilized at the latter post.

The routine care of the Army animals requires thorough daily grooming, daily exercise, grazing whenever possible, and daily veterinary inspection of the animals and the sanitary conditions under which they are kept. All animals are stabled in open-type stables.

INCIDENCE

General.—Since osteomalacia is a disease affecting the skeleton and, in the Equidæ involves usually the organs of locomotion, it is included in Group X, "Diseases of the Bones and of the Organs of Locomotion," of the International Classification of Diseases. While this group includes many conditions unrelated to osteomalacia, it is of interest to compare the incidence among Army animals in the United States with Army animals in the Philippine Islands. Both groups of animals are maintained under similar conditions with the exception of climate, feed, and water. The geographical source, the breed, the type, ages, animal management under which maintained, etc., are practically the same for each group.

Statistical data from Reports of the Surgeon General, United States Army, showing the admission rates for diseases of the bones and of the organs of locomotion among Army animals in the United States and in the Philippines for the years 1923 to 1929, inclusive, are given in Table 2 and fig. 1.

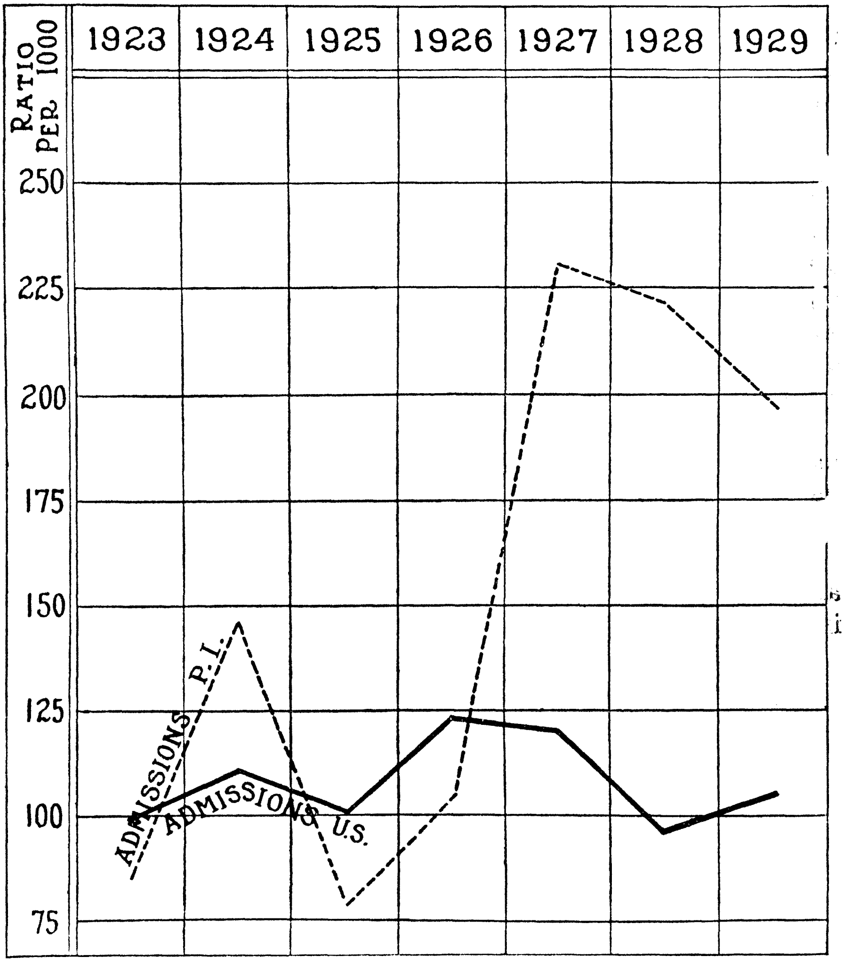


FIG. 1. Admission ratios: "Diseases of Bones and of the Organs of Locomotion."

TABLE 2.—*Admission ratios Group X: "Diseases of Bones and of the Organs of Locomotion."*

Year.	Total admission ratio per 1,000.	
	U. S.	P. I.
1923 [a]	99.20	84.28
1924 [a]	109.82	146.55
1925 [a]	100.84	79.15
1926 [a]	123.89	105.50
1927 [a]	120.45	231.13
1928 [a]	96.93	220.0
1929 [a]	106.78	192.2

[a] Abstracted from Surgeon General's Report for following year.

It will be noted that a marked increase of the admissions for diseases of this group occurred during recent years among animals in the Philippines and that the ratio is decidedly higher for Army animals in the Philippines than for like groups of animals in the United States.

Osteomalacia is an insidious disease, obscure in its initial stage, usually slow in its development, and intimately associated with other conditions that result in disturbed locomotion. While several cases of osteomalacia among Army animals in the Philippines had been reported prior to July, 1930, its importance was not recognized until after this date. The complex syndrome accompanying osteomalacia is confused easily with other conditions and a diagnosis of arthritis, obscure ringbone, sprain of joints, undetermined lameness, etc., probably was made in many instances. As previously noted in the discussion on similar diseases, osteomalacia may be related to ringbone and arthritis chronica deformans tarsi.

The incidence of diseased conditions likely to be confused with, and possibly related to, osteomalacia among Army animals in the United States and in the Philippines for the years 1923 to 1929, inclusive, are shown in Table 3 and fig. 2. These data are compiled from Reports of the Surgeon General of the Army.

TABLE 3.—*Admission rates for conditions indicated. Admission ratio per 1,000.*

Disease.	1923		1924		1925		1926		1927		1928		1929	
	U. S.	P. I.	U. S.	P. I.	U. S.	P. I.	U. S.	P. I.	U. S.	P. I.	U. S.	P. I.	U. S.	P. I.
Arthritis	9.26	12.42	14.50	18.77	14.33	9.10	18.55	6.54	16.95	22.77	11.92	25.64	14.14	13.70
Arthritis chronica deformans tarsi	8.37	6.39	8.00	19.66	6.33	15.25	10.59	8.89	9.09	20.30	9.32	12.53	12.30	31.91
Ringbone	6.97	6.45	8.85	27.49	6.06	8.23	10.47	15.17	10.99	24.54	9.09	26.60	11.71	22.44
Sprain of joints	12.76	--------	13.42	24.22	15.18	48.50	17.77	52.80	16.02	44.41	13.39	31.41	13.56	43.62
Total	37.36	25.26	44.77	90.14	41.90	81.08	57.38	83.40	53.05	112.02	43.72	96.18	51.71	111.67

It will be noted that the admissions for arthritis, arthritis chronica deformans tarsi (spavin), ringbone, and "sprain of joints" were considerably greater for the group of Army animals in the Philippines during the period 1924 to 1929, inclusive, than for the group in the United States during the same period.

With an admission rate of 34.20 cases per 1,000 for these diseases among animals in the Philippines for 1923, this rate increased threefold for 1924, or 106.30 per 1,000, and remained at a high level during the period 1925 to 1929, inclusive. The rates for 1930 are not available at this time.

It should be noted that the sudden increase in the diseases mentioned occurred in the year following the change of ration (1923).

Due to the fact that the largest group of Army animals (approximately 2,000) in the Philippines is stationed at Fort Stotsenburg, Pampanga, and that the highest incidence of the disease occurred at this station, a detailed study of the condition was made at this post. Table 4 shows the animal strength of the two largest Army posts in the Philippines and indicates the rates for osteomalacia at these stations from July 1, 1930, to July 1, 1931.

TABLE 4.—*Mean strength and osteomalacia rates; July 1, 1930, to July 1, 1931.*

Station.	Mean animal strength.	Total animals affected.	Annual ratio per 1,000.
Fort William McKinley	684.01	94	137.4
Fort Stotsenburg	2,139.55	340	158.9

The veterinary records on file at Fort Stotsenburg furnish a complete history of the animal conditions at this post from 1922 to date. All animals at the post, with the exception of a small group of horses owned by officers, are definitely identified by means of the Preston Brand System, which was adopted in 1924. The Preston brand number is entered on all records pertaining to the animal, thus furnishing a complete veterinary history of each individual since June, 1924. An analysis was made of all records from January 1, 1925, to October 1, 1931. During the period June, 1922, to January, 1925, one case of osteomalacia (diagnosed as osteoporosis) was recorded. This occurred in 1924.

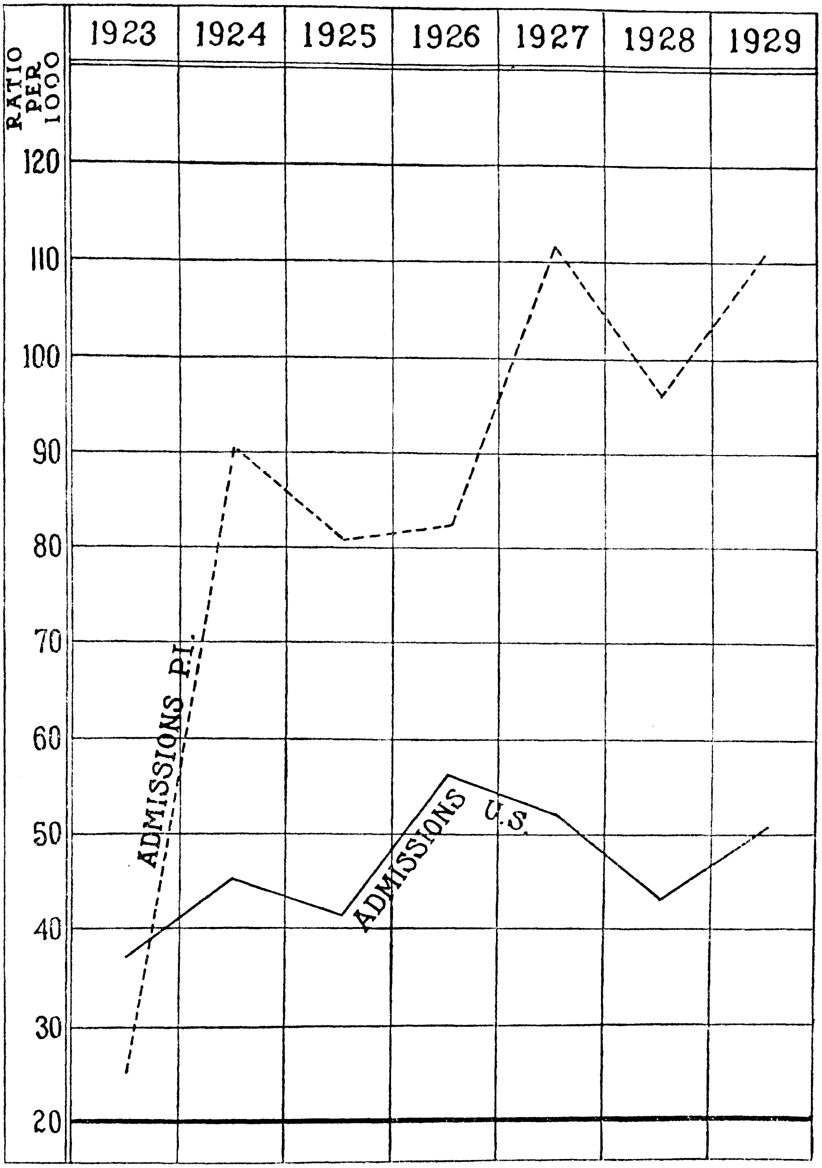


FIG. 2. Admission rates for conditions indicated in Table 3.

Table 5 shows that from January 1, 1925, to October 1, 1931, a total of 366 cases of osteomalacia were recognized. Of these cases, 340, or approximately 93 per cent, were diagnosed during the period July 1, 1930, to July 1, 1931.

TABLE 5.—*Showing in detail the cases of osteomalacia at Fort Stotsenburg from January 1, 1925, to October 1, 1931.*[a]

Year.	Period.	Species.	Status.		Sex.		Type.			Age.									
			Private mount.	Public animal.	Gelding.	Mare.	Riding.	Draft.	Pack.	4 years.	5 years.	6 years.	7 years.	8 years.	9 years.	10 years.	11 years.	12 years.	13 years.
1928	Entire year	Horse		1	1		1											1	
1929	do	do		3	1	2	3								1		1	1	
1930	January, February, March																		
	April, May, June	Horse	1	2	3		3					1					1		
	July, August, September	Horse		14	10	4	14					1		1	2	2	3	3	2
		Mule		7	4	3		3	4						1	4		1	
	October, November, December	Horse	4	62	52	14	65		1	1	1	1	1	2	10	10	14	13	6
		Mule		12	7	5		3	9		1		3		1		1	3	1
	Entire year	Horse	5	78	65	18	82		1	1	1	3	1	3	12	12	18	16	8
		Mule		19	11	8		6	13		1		3		2	4	1	4	1
		Total	5	97	76	26	82	6	14	1	2	3	4	3	14	16	19	20	9
1931	January, February, March	Horse	4	107	86	25	108	3			2	4	4	7	8	10	14	12	15
		Mule		40	23	17		15	25		1	1	5		3	3	2	5	2
	April, May, June	Horse		57	43	14	54	1	2		2	1	2	3	4	3	6	10	7
		Mule		33	23	10		7	26			3	1	2	3	2	6	2	5
	July, August, September	Horse	1	7	7	1	8						1	1			1		1
		Mule		11	5	6		5	6			1	1	1	2		1	1	
	January 1 to October 1	Horse	5	171	136	40	170	4	2		4	5	7	11	12	13	21	22	23
		Mule		84	51	33		27	57		1	5	7	3	8	5	9	8	7
		Total	5	255	187	73	170	31	59		5	10	14	14	20	18	30	30	30
Cases January 1, 1925, to October 1, 1931[a]		Horses	10	253	203	60	256	4	3	1	5	8	8	14	25	25	40	40	31
		Mules		103	62	41		33	70		2	5	10	3	10	9	10	12	8
		Total cases	10	356	265	101	256	37	73	1	7	13	18	17	35	34	50	52	39

Year.	Period.	Species.	Age.												Disposition.				Total cases.
			14 years.	15 years.	16 years.	17 years.	18 years.	19 years.	20 years.	21 years.	22 years.	23 years.	25 years.	25 years and over.	Destroyed.	Died concurrent condition.	Duty.	Remaining under treatment.	
1928	Entire year	Horse													1				1
1929	do	do													3				3
1930	January, February, March																		0
	April, May, June	Horse		1											3				3
	July, August, September	Horse													13		1		14
		Mule		1											6		1		7
	October, November, December	Horse	4		1				1		1				55		11		66
		Mule										1		1	11		1		12
	Entire year	Horse	4	1	1				1		1				71		12		83
		Mule		1								1		1	17		2		19
		Total	4	2	1				1		1	1		1	88		14		102
1931	January, February, March	Horse	3	2	2		1	5	3	8	1	5	4	1	72		38	1	111
		Mule	1	1	1	1		4		2	2	2	2	2	34		6		40
	April, May, June	Horse	6	2				2	1	4	2		2		16	1	35	5	57
		Mule	1						1	1		1	4	1	5		22	6	33
	July, August, September	Horse		1			1	2							3		5		8
		Mule			1	1				2					2		6	3	11
	January 1 to October 1	Horse	9	5	2		2	9	4	12	3	5	6	1	91	1	78	6	176
		Mule	2	1	2	2		4	1	5	2	3	6	3	41		34	9	84
		Total	11	6	4	2	2	13	5	17	5	8	12	4	132	1	112	15	260
Cases January 1, 1925, to October 1, 1931[a]		Horses	13	6	3		2	9	5	12	4	5	6	1	166	1	90	6	263
		Mules	2	2	2	2		4	1	5	2	4	6	4	58		36	9	103
		Total cases	15	8	5	2	2	13	6	17	6	9	12	5	224	1	126	15	366

[a] No cases recorded from January 1, 1925, to July 16, 1928.

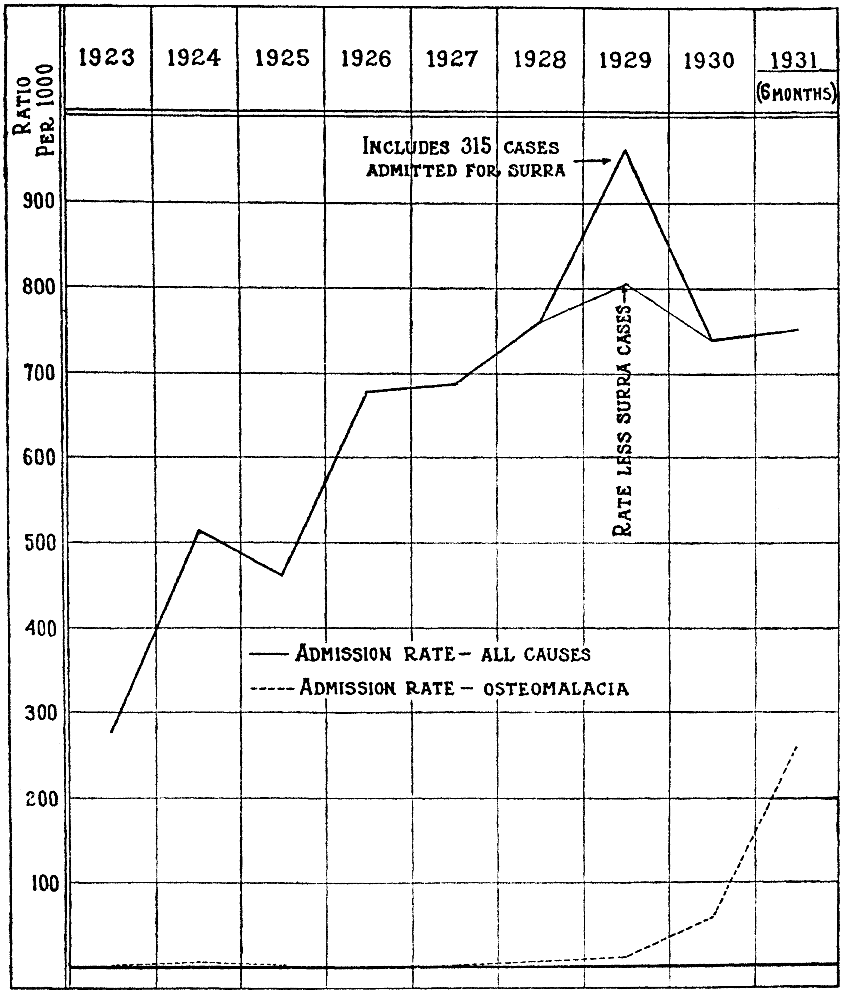


FIG. 3. Comparison of osteomalacia admission rates with total admission rates.

Table 6 shows the number of cases of the disease by year and the annual ratio per 1,000.

A comparison of the incidence of osteomalacia with all causes of admission to sick report is shown in Table 7 and fig. 3.

It will be noted, as shown in Table 7 and fig. 3, that a decided increase in the admission rate for all causes occurred in 1924, one year following the change of ration. While this rate decreased somewhat in 1925, it remained at a uniformly high level from 1926 to July 1, 1931, with the exception of a sharp increase of total admissions in 1929, which was due to an epizoötic of surra, when 315 cases of this disease were admitted. The admission rate for osteomalacia was of little significance until 1930 when a marked increase occurred. It should be noted, as shown in fig. 3, that a decided increase in admission for osteomalacia occurred in 1930 and 1931. This increase did not affect the total admission rate. That the latter rate is affected markedly by admission of approximately 300 cases is indicated by the increased rate for 1929 when the surra outbreak occurred in the command. In 1931, during the first six months, 285 admissions for osteomalacia were recorded, a ratio of 570 cases per year. This large number of admissions did not affect the total admission rate. For the above reasons, it is believed that osteomalacia was much more prevalent in the command prior to 1930 than the records indicate.

The incidence of osteomalacia as compared with total admissions, for the period July 1, 1930, to July 1, 1931, is shown in fig. 4.

During the period indicated in fig. 4, 1,666 animals were admitted to sick report. Of this total 395, or 23.7 per cent, were admitted for osteomalacia.

Status.—Referring to Table 5, it will be noted that Army animals are divided into two groups; namely, private mounts and public animals. The group of private mounts includes approximately 86 horses owned by officers and used by them in the Army service; the group of public animals is composed of Government-owned horses and mules used by the Army. Private mounts are animals of superior type, conformation, and quality, and are better bred usually than are the horses of the public-animal group. The conditions under which the two groups of horses are maintained differ somewhat. The feed of the former

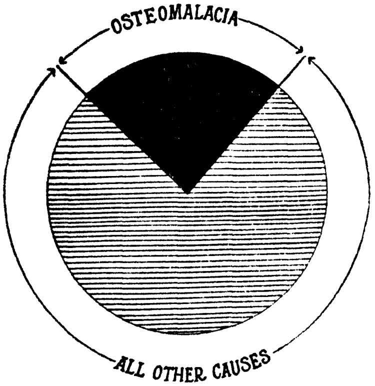


FIG. 4. Comparison of admissions for osteomalacia and admissions for all other causes.

TABLE 6.—*Osteomalacia at Fort Stotsenburg, January 1, 1925, to October 1, 1931.*

Year.	Animals affected.	Annual ratio per 1,000.
1925	0	
1926	0	
1927	0	
1928	1	0.46
1929	3	1.55
1930	102	50.89
1931 [a]	260	171.22
Total	366	

[a] Nine months.

TABLE 7.—*Admissions and rates. Comparison of osteomalacia with all causes.*

Year.	Mean strength.	Admissions.		Annual admission ratio per 1,000.	
		All causes.	Osteomalacia.	All causes.	Osteomalacia.
1923	2,192	619		277.8	
1924	2,112	1,087	1	514.7	0.5
1925	2,157	989		458.5	0
1926	2,335	1,586		679.2	0
1927	2,308	1,579		684.1	0
1928	2,176	1,653	1	759.7	0.5
1929	1,994	[a] 1,916 [b] 1,601	3	[a] 960.9 [b] 802.9	1.5
1930	2,004	1,495	114	746.0	56.9
1931 [c]	2,117	797	285	752.9	269.2

[a] Total admissions and total admission rate.

[b] Admissions and rate less 315 cases of surra, which occurred during 1929.

[c] Six months.

group consists usually of American oats and American hay with an occasional addition of wheat bran, while the latter group is fed the prescribed Army ration. It will be noted in Table 5 that ten cases of osteomalacia occurred in animals of the private-mount group during 1930 and the first nine months of 1931, while 249 cases occurred in horses of the public-animal group. Based on the mean animal strength of these two groups (86 private and 797 public) 11.6 per cent of the private mounts and 31.2 per cent of horses belonging to the public group developed osteomalacia.

No definite conclusions are drawn with relation to the difference in incidence of osteomalacia between these two groups for the following reasons: (1) The ration fed to private mounts varies somewhat with the individual owner. Details regarding the ration for this group were unobtainable for the period noted. (2) The length of service in the Philippines for animals of the private-mount group is much shorter usually than is the case in the public-animal group. The tour of service for private mounts corresponds generally to that of the owners (two to three years). The public animals in the Philippines rarely are returned to the United States.

Species.—As already noted 366 cases of osteomalacia were recorded during the period January 1, 1925, to October 1, 1931; 340 cases, or approximately 93 per cent, were diagnosed during the period July 1, 1930, to July 1, 1931. It is believed that a more accurate picture of the incidence of the disease among horses, as compared with mules, is afforded by consideration of the cases occurring during the latter period, as the full significance was recognized during this period only.

Of the 340 animals affected during the period July 1, 1930, to July 1, 1931, 251 were horses and 89 mules. The incidence rates, based on the mean animal strength of the command during the period noted, are shown in Table 8.

TABLE 8.—*Species incidence.*

Species.	Animals affected.	Mean animal strength.	Annual ratio per 1,000.
Mule	89	1,204	73.9
Horse	251	936	268.3
Total	340	2,140	158.9

The incidence rate for osteomalacia per 1,000 mules during the period July 1, 1930, to July 1, 1931, was 73.9; the rate for horses was 268.3. The ratio of affected mules to horses was 1: 3.6, indicating that mules are far more resistant than horses to osteomalacia. Further evidence of this is shown by the fact that of 351 horses and 734 mules shipped to Fort Stotsenburg during the period 1927 to 1931 of which records are available, 15 per cent of the horses and only 4 per cent of the mules developed osteomalacia. The statement of Law(7) that mules habitually escape the disease did not apply in these animals.

Sex.—The Army purchases three geldings to one mare, approximately. Records showing the number of animals of each sex present in the command during the periods considered were unobtainable. Of the 366 cases recorded, 102 occurred among mares and 264 among geldings, which is a 1: 2.6 ratio of affected mares to geldings. Since the geldings outnumber the mares by approximately three to one, it is believed that geldings and nonpregnant mares are affected equally. All investigators admit that pregnancy may influence the development and/or the course of the disease.

Age.—Analysis of the records indicates that osteomalacia may occur at any age beyond 4 years. Well-developed cases were noted in animals 25 years old. Table 5 shows the age of each case recorded, while fig. 5 shows the number of cases by age groups of two years and the percentage of total cases in each group.

Age ratios are not given because available records do not indicate the age of each animal in the command during the period considered.

Of the 366 cases recorded 266, or 73 per cent, occurred in animals of the age group 4 to 13 years. The age group 9 to 13 years included 210 cases, or 57 per cent of the total. The average age for all affected animals was 12.6 years; for affected horses, 12.1 years; and for affected mules, 13.4 years.

Comment.—1. The prevalence of osteomalacia is reported in Army animals in the Philippine Islands.

2. Diseases affecting the bones and organs of locomotion are more prevalent in Army animals in the Philippines than in like animals in the United States. The incidence of this group of diseases among the former showed a marked increase in 1924, approximately one year after a change of ration from imported to one composed largely of native feed.

3. It is believed that osteomalacia was prevalent in Army animals in the Philippines prior to its recognition in a large number of cases during 1930 and 1931. It was responsible for 23.7 per cent of all admission to the sick and wounded report at Fort Stotsenburg during the period July 1, 1930, to July 1, 1931.

4. It is believed that many conditions diagnosed as arthritis, ringbone, spavin, etc., were in reality osteomalacia.

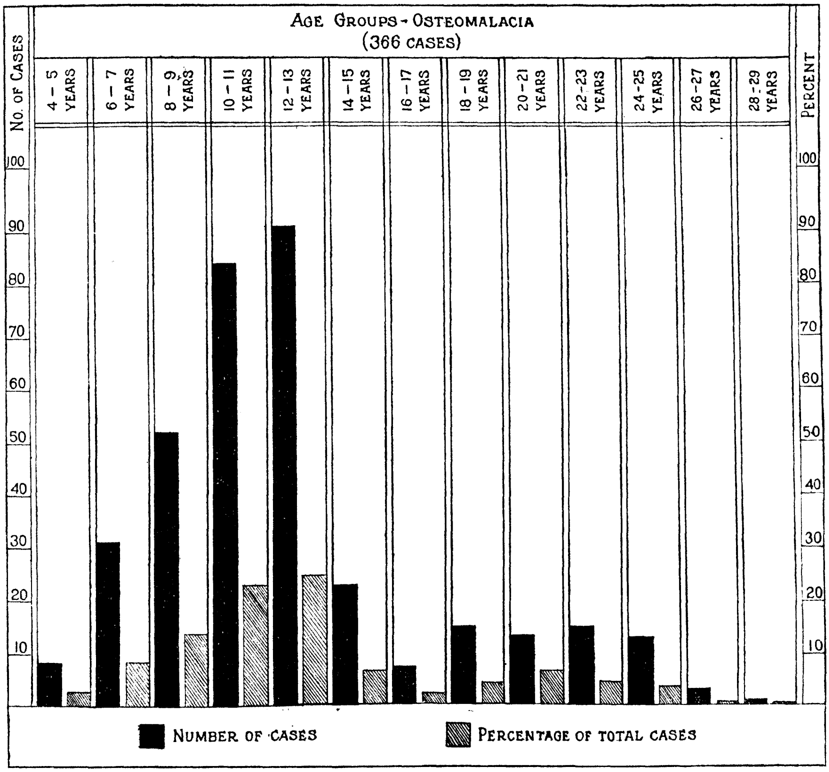


FIG 5. Number of cases and percentage of total in age groups of two years each.

5. Contrary to the opinion of some writers, osteomalacia affects mules as well as horses. The former animals, as compared with the latter, exhibit a marked resistance to the disease.

6. Osteomalacia may affect animals of all ages. At Fort Stotsenburg the condition was found to be prevalent particularly among animals from 6 to 13 years of age.

7. It is believed that sex is not a factor in the development and course of osteomalacia of equines.

ETIOLOGY

General.—The following conditions have been described as predisposing causes of osteomalacia in animals: Poor stable management, including lack of proper exercise and insanitary conditions, insufficient sunlight, insufficient or improper feed, etc. Others believe that infections, toxæmias, heredity, etc., have an influence on the development of the disease. In the literature there is a wide diversity of opinion as to whether any of the conditions mentioned actually do predispose. Law(7) states that city environment is an important contributing factor in horses, and quotes Bern, who noted that cases removed from Brooklyn, New York, to the country usually recovered. Other investigators remark upon the high incidence of the disease among city horses as compared with animals maintained in the country. Statements of this character, however, are indefinite and details of animal management, feed, water, exercise, etc., usually are not given.

In the present investigation, dealing almost exclusively with Army animals, adverse conditions of management were not involved. These animals are maintained under excellent conditions. It was noted that hard work tended to increase the number of cases.

The multiplicity of exciting causes listed in the literature indicates the uncertainty that has existed as to the actual cause of the disease. Many investigators state that the cause is unknown. Among the many theories of cause advanced at various times are disturbances of internal secretion, parasitic infestation, heredity, infection, vitamin deficiency, and mineral deficiencies.

Disturbance of internal secretion.—Many writers believe in this theory, and it is claimed that different glands have been incriminated at one time or another. Winslow(6) states that Bossi has produced osteomalacia in sheep by removal of one suprarenal gland and that he has cured the condition in humans by injections of adrenalin. White(25) advances the theory that disturbances in ductless glands might reduce the alkalinity of the blood, thus permitting the lime salts to be dissolved. In various investigations of this disease, the ovary, parathyroid, and thymus have been held to be responsible.

In the present investigation, no gross abnormalities have been noted in the glands having internal secretions.

Parasitic infestation.—According to Roberts,(36) Conveur of Brazil believes that equine osteomalacia is due to cylicostome infestation. He found all cases to be grossly infested with this intestinal parasite and states that the administration of vermifuges resulted in improvement or recovery.

Heavy infestation with intestinal parasites was not noted in the present investigation; further, eosinophilia, a recognized indication of parasitism, was not demonstrated.

Heredity.—Bordeaux(9) in 1924 stated that, while the exact cause of osteomalacia of horses is unknown, inheritance and work are very strong predisposing factors. This writer suggests that heredity may have an influence and relates personal observations of six sires all of which produced a high percentage of offspring that developed the disease. Gonzales and Villegas(37) believe that osteoporosis of horses is a constitutional disease that is heritable.

That heredity may be a factor in the development of osteomalacia in some instances is conceivable when the work of Kramer and Howland,(38) Goldblatt,(39) and others is considered. The former investigators showed that a mineral defect in the diet is accentuated in succeeding generations of rats. Goldblatt demonstrated that rats whose parents had received cod-liver oil before and during pregnancy were better able to withstand the effects of deficient diets. The percentage of calcium in their bones was higher than in rats whose parents did not receive cod-liver oil. Both the above experiments indicate that mineral substances and vitamins may be stored in the offspring of animals.

In the present investigation there was no evidence that heredity exerted an influence in the development of the disease. Many typical cases appeared in animals over 20 years of age, and it is probable that the disease would have appeared long before this advanced age had been attained if heredity had exerted an influence.

Infection.—According to Hutyra and Marek,(12) this theory is finding more and more adherents. They state that Morpurgo, Moussu, Petrone, Pécaud, and others believe in this theory. Robertson(2) maintains that the condition is caused by a specific organism, although he obtained negative results on examination of blood and tissue specimens from affected animals. The contentions of this writer are based on an epizoölogical study of the disease in the Union of South Africa. Theiler(40) supports the theory of infection but failed to produce the disease by inoculation experiments. This investigator suggests that the microörganism or virus may be transmitted by insects. Lienaux(41) claims that osteomalacia may be produced by inoculation in small laboratory animals. Elliot(14) believes that the disease is due probably to an infection that enters the animal's body through wounds. Law(7) states that Berns, Hoskins, and others have noted that "a fresh horse put in the stall of one that had suffered from osteoporosis soon contracted the disease." White(8) states that the disease is due probably to infection, as the change in the affected bones are of the character of infectious inflammations. Ingle(16) claims that the disorder is due to an infection that develops in animals rendered susceptible by defective diet. Henry(42) is opposed to the theory of infection, basing his opinion on the observation that affected cattle removed to nonaffected areas recovered from the disease. Mohler(1) quotes the experiments of Peason who obtained negative results by blood inoculations and bone transplants from affected to normal horses. Sturgess(10) and others do not support the theory of infection.

EXPERIMENTS

We observed that four of six advanced cases of osteomalacia under prolonged observation exhibited a moderate leucocytosis, intermittent in character and undetermined as to origin. This fact together with the epizoölogical study of the disease at Fort Stotsenburg, where a large number of cases were recognized in a short period of time, led the writers to investigate the theory of infection. This experiment was based on a bacteriological study of the disease, animal inoculation, and insect transmission.

Experiment 1.—March 1, 1931, the following animal was transferred to the board for experimental purposes: Species, horse; sex, gelding; age, 11 years; weight, 975 pounds; type, riding; color, roan. Diagnosis, osteomalacia, actively progressing type. Clinical examination confirmed the diagnosis. The animal showed a moderate shortening of the stride in all extremities. There were moderate proliferative changes along the lateral superior border of the rami of the mandible adjacent to the molar teeth, and slight enlargement of the facial bones. A "tucked-up" appearance of the flank was present and some deformity of the thorax was evidenced by a peculiar protruding appearance of the shoulder joints. The temperature was normal. The leucocyte count was 9,300, composed as follows: Monocytes, 2 per cent; lymphocytes, 47 per cent; neutrophylic granulocytes, 48 per cent (segmented, 40 per cent and "staff" or "band" forms, 8 per cent); eosinophiles, 2 per cent; mast cells, 1 per cent. The serum calcium was 12.5 milligrams per 100 cubic centimeters; and the inorganic phosphorus, 4.2 milligrams per 100 cubic centimeters. X-ray examination of the large metacarpal bone showed a slight rarefaction of the cortex. The animal was destroyed March 3 and autopsy confirmed the diagnosis.

Specimens of synovia from the humeroscapular and coxofemoral joints, bone marrow from the femur and humerus, and sections of bone from the metacarpals were collected under aseptic precautions. Blood specimens were collected under aseptic conditions immediately prior to destruction of the animal. Aërobic and anaërobic cultures were prepared from these specimens using veal-infusion broth, veal-infusion agar, Nicolle-Novy-MacNeal media, dextrose broth, fresh beef-heart broth, cystine agar, and veal-infusion broth to which had been added small sections of osteomalacic bone. After forty-eight hours incubation at 37.5° F., the following aërobic and anaërobic cultures of the synovia, bone, and bone marrow showed the presence of a Gram-negative coccobacillus; dextrose broth, beef-heart broth, and veal-infusion broth containing bone. No growth developed in the blood specimen cultured. The organisms isolated from the synovia, bone marrow, and bone appeared to be identical.

Three cubic centimeters of a 48-hour veal-infusion-broth culture of this organism was injected intravenously into a normal horse. This animal was observed for a period of six months during which time no sign of osteomalacia appeared. Inoculation of the organism into rabbits, guinea pigs, white rats, and white mice gave negative results.

An agglutinating antigen was prepared from the organism by suspending it in physiological saline solution. Agglutination tests were made on the serum from five clinical cases of osteomalacia; negative results were obtained in all cases. A broth culture of the organism was used as an antigen for complement-fixation tests on five clinical cases of the disease; negative results were obtained in all cases. Ten days after inoculation of the horse, rabbits, and guinea pigs, with the coccobacillus, sera from these animals were tested for agglutinating and complement-fixing properties; negative results were obtained in all instances.

Experiment 2.—April 16, 1931, an advanced case of osteomalacia was destroyed and specimens of synovia and bone marrow collected for bacteriological examination. Aërobic and anaërobic cultures were prepared from these specimens, using blood-agar plates, veal-infusion broth, and beef broth to which small sections of osteomalacic bone had been added. Negative results were obtained with all specimens.

Experiment 3.—The intermittent leucocytosis exhibited by some cases of osteomalacia and for which no other cause was apparent, suggested the possibility of a "low-grade" infection. Repeated blood cultures were made from three cases of this type. In each instance specimens were collected on the day preceding a high leucocytic count. Aërobic and anaërobic cultures were prepared, using various culture media. Fig. 6 shows the type case under discussion and is representative of other cases that were cultured. Specimens were taken from this animal October 13, 17, 22, and 26, 1930. Negative results were obtained in all instances.

Experiment 4.—The suggestion by Theiler(40) that a virus or microorganism carried by insects might be responsible for osteomalacia, prompted the writers to undertake an experiment based on this theory. Two lots of laboratory-bred mosquitoes (78 female *Culex quinquefasciatus* and 92 female *Aëdes ægypti*) were allowed to feed on horse 1C09 October 13, 1930. This animal showed clinical symptoms of osteomalacia. On the day the insects fed the leucocytic count was 12,700. The leucocyte count on the following day was 13,450. After periods of seven and fourteen days these lots of mosquitoes were allowed to feed on a normal horse. The temperature and blood count of this animal remained normal for a period of one month, and the animal was observed for a period of eight months. No signs of osteomalacia developed during this period.

Experiment 5.—October 23, 1930, 50 cubic centimeters of blood was removed from horse 1C09 and injected into the jugular vein of a normal horse. Animal 1C09 showed definite clinical symptoms of osteomalacia, and the leucocytic count was 12,700 on the day blood was collected for inoculation. The inoculated animal was observed for a period of five months; no sign of osteomalacia developed.

Comment.—As shown by the above experiments, no evidence was obtained indicating that equine osteomalacia as observed in the present investigation was caused by an infection.

Vitamin deficiency.—Following the discovery of vitamins, Funk(43) suggested that rickets was caused by lack of a specific vitamin responsible for normal mineral metabolism of bone. Mellanby(44) conducted the first experiments on the antirachitic food factor in 1919. Following the discovery that there is present in cod-liver oil a fat-soluble factor capable of influencing the deposition of calcium salts in the skeleton, considerable confusion existed as to the identity of this vitamin. Many investigators demonstrated that cod-liver oil contained a substance or substances capable of influencing growth and preventing xerophthalmia and influencing mineral metabolism. This substance was termed "vitamin A." In 1920, Hopkins(45) first demonstrated that, while vitamin A displayed a marked resistance to heat alone at a temperature up to 120° F., it was readily destroyed by oxidation. Later in the same year, Drummond and Coward(46) confirmed the work of Hopkins. This has since been confirmed by many investigators. In 1922, McCollum, Simmonds, and Becker(47) and McCollum, Simmonds, Becker, and Shipley(48) demonstrated conclusively that cod-liver oil contained a vitamin separate and distinct from the antixerophthalmia factor. These investigators showed that oxidized cod-liver oil did not cure xerophthalmia (vitamin A destroyed), but was equally effective in the cure of rickets as the unoxidized oil. This new substance was antirachitic or calcium depositing in its action and is now known as "vitamin D." Following the work of McCollum and others, many investigators demonstrated conclusively that vitamin D has a marked influence on calcium metabolism, and the lack of this factor is now believed to be the cause of human osteomalacia.

For many years investigators had noted that sunlight seemed to exert a beneficial effect in the prevention of diseases involv-

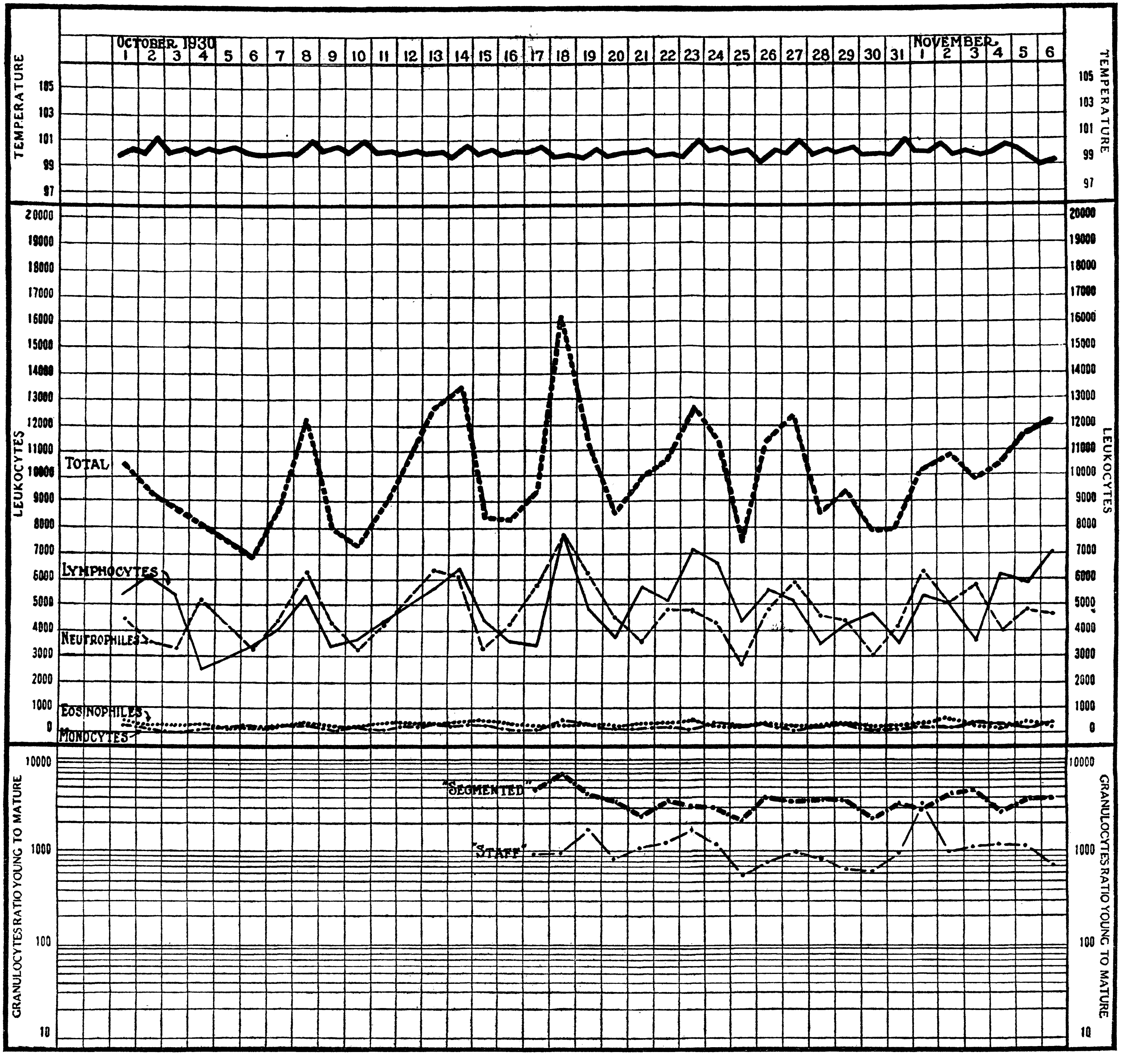


FIG. 6. Leucocyte count and temperature; chart of horse 1C09.

W. O. 269252. Facing page 28.

ing the bones and in arresting these conditions. In 1924, Steenbock, Hart, and Jones(49) showed that direct sunlight improved the mineral metabolism of pigs. These investigators also demonstrated that while grains contained but little vitamin D, fresh green plant material is rich in this factor. In the same year Hess(26) showed that ultra-violet radiation of food imparted antirachitic properties to the substance so treated. Following the discovery that sunlight and ultra-violet rays stimulated the utilization of calcium in the animal body, many experiments have been conducted in an attempt to group or classify the species of animals that are benefited by these rays. In 1926, Hart, Steenbock, Elvehjem, and Scott,(50) working with milk cows, determined that sunlight had a feeble action on the utilization of calcium by these animals. In the same year, Eckels, Becker, and Palmer,(51) working with the same species of animal, suggested that the seasonal variation of mineral-deficiency diseases noted in these animals was probably due to variations in the ultra-violet content of sunlight. A year later, Hart, Steenbock, and Scott(52) found that ultra-violet rays had very little if any effect on the calcium and phosphorus metabolism of dairy cows. These writers suggest that in the cow the antirachitic vitamin is derived from the feed and in this respect the cow differs from man, goats, chickens, and probably rats.

Reid(17) believes that vitamin deficiencies are of little importance in diseases of animals. He states that investigators have shown that vitamins are frequently lost or destroyed during preparation of food for human consumption while this is not true of food consumed by animals.

While some investigators report beneficial results in equine osteomalacia by the administration of cod-liver oil, and most textbooks on the subject recommended its use, it has not proved to be beneficial in all cases. Sturgess(10) observed one case of the disease that was treated with one pint of cod-liver oil daily with no improvement. The concensus of opinion seems to be that vitamin D is an accessory factor in the etiology of equine osteomalacia.

EXPERIMENTAL

In order to determine the influence of vitamins on the course of equine osteomalacia and to test the efficacy of imported hay and oats together with the influence of large amounts of fresh green grass, the writers conducted the following experiment:

Feeding experiment 1.—This was begun November 11, 1930, and the following animals, all of which exhibited symptoms of osteomalacia, were placed in a feeding group:

Horse B776.—Sex, gelding; color, bay; age, 13 years; weight, 710 pounds. Diagnosis of osteomalacia was made August 14, 1930. When examined November 11, the animal showed a marked shortening of the stride in all legs. There was a pronounced thickening of the rami of the mandible and slight proliferative changes of the facial bones. Some thoracic deformity was present as evidenced by a protruding appearance of the shoulder joints. The general condition was poor, and the hair coat of fair appearance. The serum calcium was 8.96 milligrams; and the inorganic phosphorus, 3.5 milligrams. X-ray examination of the metacarpal bone showed a moderate rarefaction and thinning of the cortex.

Horse B760.—Sex, gelding; color, brown; age, 12 years; weight, 750 pounds. Sick record showed a diagnosis of osteomalacia for this animal August 14, 1930. Clinically the animal showed a marked shortening of the stride in all four legs. There were marked proliferative changes of the mandible, and the facial bones showed a moderate enlargement. Slight deformity of the thorax was present (see Plate 1). The general condition and hair coat were fair. Serum calcium was 9.4 milligrams and inorganic phosphorus, 3.45 milligrams, per 100 cubic centimeters. The X-ray examination showed a slight rarefaction of the cortical portion of the metacarpal bone (see Plate 2).

Horse 249C.—Sex, gelding; color, black; age, 12 years; weight, 1,170 pounds. Sick record showed a diagnosis of osteomalacia for this animal November 10, 1930. The animal exhibited a moderate shortening of the stride in all legs. There were moderate proliferative changes of the bony tissue along the superior border of the rami of the mandible. No changes were noted in the facial bones. The general condition and hair coat were good. This animal showed a marked deformity of the thorax, exhibited by a protruding appearance of the shoulder joints and a sunken appearance of the sternum. The serum calcium was 9.45 milligrams and the inorganic phosphorus, 4.0 milligrams. X-ray examination of the metacarpal bone showed a moderate rarefaction of the compact portion.

Horse C442.—Sex, gelding; color, light chestnut; age, 11 years; weight, 870 pounds. Sick report showed a diagnosis of osteomalacia September 20, 1930. Clinical examination November 11, 1930, showed that this animal had a marked shortening of the stride in all four legs. There were marked proliferative changes of the rami of the mandible and enlargement of the facial bones. This animal showed the characteristic prominence of the shoulders and sunken appearance of the sternum (see Plate 3). The calcium content of the blood serum was 8.8 milligrams per 100 cubic centimeters; and the inorganic phosphorus, 3.96 milligrams. X-ray examination showed a moderate rarefaction of the metacarpal bone (see Plate 4, fig. 1).

Horse 74B9.—Sex, mare; color, dark chestnut; age, 7 years; weight, 950 pounds. Sick report showed a diagnosis of osteomalacia October 5,

1930. The animal showed a moderate shortening of the stride in the front legs while a slight shortening was present in the hind legs. There was a moderate thickening of the upper border of the rami of the mandible and moderate enlargement of the facial bones (see Plate 5). The serum calcium was 10.6 milligrams per 100 cubic centimeters; and the inorganic phosphorus, 5.64 milligrams. X-ray examination showed a slight rarefaction of the metacarpal bone (see Plate 6, fig. 1). The general condition and hair coat were good.

Animals B776, B760, and 249C were fed a basal ration composed of 2 pounds of American oats, 1 pound of crushed palay, 2 pounds of copra meal, 7 pounds of American grain hay, and 7 pounds of native rice hay. This ration is similar in composition to the ration fed regularly to Army animals in the Philippines with the exception that the green-grass component is omitted from the former ration. The nutritive ratio of the digestible crude protein and the combined digestible carbohydrates and fat (1: 8.4) is within the limits prescribed for horses.(53) Chemical composition of products mentioned in all rations was computed from Table 19. During the feeding experiment, horse B776 received vitamins A and D in the form of cod-liver oil (United States Pharmacopœia), 300 cubic centimeters being administered daily. Horse B760 was given 10 cubic centimeters of Viosterol daily during the feeding period. No vitamins were added to the ration of horse 249C, this animal serving as control. The calcium-phosphorus content of this ration was CaO, 14.2, grams; P_2O_5, 33.4 grams; a ratio of 1: 2.4.

While the primary object of this experiment was to determine the influence of vitamins A and D on the course of osteomalacia, it was thought desirable to determine the value of a large amount of green grass and the effect of a ration composed entirely of imported feed. Therefore, two animals were added to the feeding group:

Horse C442.—This animal received the same grain allowance as horses B776, B760, and 249C. The roughage portion of the ration was composed of American grain hay, 4 pounds; native rice hay, 4 pounds; and native green grass (commonly termed zacate), 18 pounds. The nutritive ratio of the ration was 1 : 7.7. The calcium-phosphorus content was CaO, 18.7 grams; P_2O_5, 45 grams; a ratio of 1 : 2.4.

Horse 74B9.—This animal was maintained on a ration composed of 5 pounds of American oats, 0.5 pound of American wheat bran, and 14 pounds of American grain hay. The nutritive ratio of this ration was 1 : 7.8. The calcium-phosphorus content was CaO, 13.6 grams; P_2O_5, 31.6 grams; a ratio of 1 : 2.3.

During the day all animals of the group were kept in a large corral where drinking water was available at all times. Chemical analysis of this water showed a calcium content of 19.5 parts per million (see Table 20). Salt in the form of compressed blocks was available to the animals at all times.

The progress of the disease is shown in detail in fig. 7.

While frequent clinical examinations of the experimental animals were of value, it was found that the course of osteomalacia could be followed with greater accuracy by X-ray examinations of the bones. (For details and technic, see page 72.) X-ray pictures of all experimental animals were made at frequent intervals for comparison, and this procedure furnished the most accurate means of determining whether the process was active, arrested, or healing.

As shown in fig. 7, slight clinical improvement was noted in the animal (B776) receiving cod-liver oil, and the pathological process in the bone, as shown by X-ray, was arrested apparently. The animal (B760) receiving vitamin D and the control animal (249C) both showed on clinical and X-ray examinations that the disease was active and progressing. An X-ray picture taken November 11, 1930, of the left metacarpal bone of horse B760 is shown in Plate 2, fig. 1; Plate 2, fig. 2, of the same animal was taken January 27, 1931. It will be noted in Plate 2, fig. 2, that the rarefaction was increased in the anterior part of the cortical portion and the posterior part of the compact bone shows a definite thinning.

The animal (C442) that received the green grass and the animal (74B9) maintained on imported feed, both showed definite evidence that the disease was progressing. Plate 4, figs. 1 and 2, shows the condition present in the metacarpal bone of horse C442, at the beginning and end of the experiment and Plate 6, figs. 1 and 2, shows the metacarpal bone of horse 74B9.

The serum calcium of the animal (B760) receiving Viosterol showed an increase of 17 per cent and that of animal (B776) receiving cod-liver oil showed an increase of 14 per cent; the control animal showed an increase of 8 per cent. The serum calcium of the animal (C442) receiving a large amount of green grass, showed an increase of 5 per cent and the animal (74B9) maintained on imported feed showed an increase of 4 per cent.

Comment.—In one case of equine osteomalacia, vitamins A and D supplied by 300 cubic centimeters of cod-liver oil daily for a period of seventy-seven days arrested the condition.

ANIMAL No.	RATION	ADDED TO RATION	DATE	PHYSICAL EXAMINATION									BLOOD CHEMISTRY (MILLIGRAMS PER 100 CC SERUM)		X-RAY REPORT
				WEIGHT LBS.	HEAD LESIONS: LOWER MANDIBLE	HEAD LESIONS: FACIAL	SHOULDERS	LORDOSIS	GAIT: FRONT	GAIT: REAR	GENERAL CONDITION	COAT	CALCIUM	INORGANIC PHOSPHORUS	
B776	BASIC (1)	VITAMINS-"A AND D" 300 cc COD LIVER OIL (U.S.P.) DAILY	Nov. 11-1930	710	●●●	●	●		●●●	●●●	■■■	▲▲	8.96	3.51	●●
			DEC. 20-1930	690	●●●	●	●		●●●	●●●	■■	■■	10.20	4.00	●●
			JAN. 27-1931	710	●●●	●	●		●●	●●	■■	▲	10.20	4.17	●●
B760	do.	VITAMIN "D" 10cc VIOSTEROL-250D DAILY	Nov. 11-1930	750	●●●	●●	●		●●●	●●●	▲▲	▲▲	9.40	3.45	●
			DEC. 20-1930	750	●●●	●●	●		●●	●●●	■■	■■	10.90	4.00	●
			JAN. 27-1931	770	●●●	●●	●		●●●	●●●	■■	▲	11.00	3.33	●●
249C	do.		Nov. 11-1930	1170	●●		●●●		●●	●●	■■	■■	9.45	4.00	●●
			DEC. 20-1930	1170	●●		●●●		●●	●●●	▲▲	■■	10.03	4.00	●●
			JAN. 27-1931	1150	●●●		●●●		●●	●●●	▲▲	■■	10.20	3.23	●●●
C442	SPECIAL (2)		Nov. 11-1930	870	●●●	●●●	●●●	●	●●●	●●●	▲▲	▲▲	8.8	3.96	●●
			DEC. 20-1930	860	●●●	●●●	●●●	●	●●●	●●●	■■■	▲▲	8.0	4.00	●●
			JAN 24-1931	850	●●●	●●●	●●●	●	●●●	●●●	■■■	▲▲	9.2	5.26	●●●
74B9	AMERICAN (3)		Nov. 11-1930	950	●●	●●			●●	●	■■	■■	10.6	5.64	●
			DEC 20-1930	950	●●	●●			●●		■■	■■	10.6	4.35	●●
			JAN. 24-1931	960	●●●	●●●			●●		■■	■■	11.0	4.56	●●

● = SLIGHT OR MILD
●● = MODERATE
●●● = MARKED OR SEVERE

■ = EXCELLENT
▲ = VERY GOOD
■■ = GOOD
▲▲ = FAIR
■■■ = POOR

(1) BASIC RATION (DAILY)
OATS, ... 2 lbs.
PALAY (CRUSHED), ... 1 lb.
COPRA MEAL, ... 2 lbs.
AMERICAN GRAIN HAY, .. 7 lbs.
RICE HAY, ... 7 lbs.

(2) SPECIAL RATION (DAILY)
OATS, ... 2 lbs.
PALAY (CRUSHED), ... 1 lb.
COPRA MEAL, ... 2 lbs.
AMERICAN GRAIN HAY, ... 4 lbs.
RICE HAY, ... 4 lbs.
GREEN FORAGE, ... 18 lbs.

(3) AMERICAN RATION (DAILY)
OATS, ... 5 lbs.
WHEAT BRAN, ... ½ lb.
AMERICAN GRAIN HAY, ... 14 lbs.

FIG. 7. Feeding experiment 1.

Slight improvement was noted in the clinical symptoms, the serum calcium was increased 14 per cent, and no extension of the rarefaction was apparent in the metacarpal bone.

Vitamin D in the form of Viosterol, administered in 10 cubic centimeters doses daily for a period of seventy-seven days, failed to arrest the condition. Clinical symptoms showed no improvement, and the X-ray examination of the metacarpal bone showed an extension of the rarefaction. The serum calcium was increased 17 per cent.

Large amounts (18 pounds) of fresh green grass, fed for a period of seventy-four days, not only failed to arrest the condition but the disease progressed.

A ration composed of imported oats, wheat bran, and American grain hay failed to arrest the condition.

In the rations used, the ratio of calcium to phosphorus was between 1: 2.3 and 1: 2.4.

Mineral deficiency.—The theory of mineral deficiency as the cause of osteomalacia is supported by many investigators, but Mohler,(1) Theiler,(40) Robertson,(2) Elliot,(14) and others state that the condition is not caused by dietetic deficiencies. Of the many writers who support the theory of mineral deficiency, some believe that the disease is due to a lack of calcium in the diet or drinking water, others claim that a lack of phosphorus is responsible, while still others state that the condition is caused by an unbalanced ratio of the calcium and phosphorus intake. Henry(42) believes that a mineral deficiency is the cause and states that there is a correlation between soils deficient in lime and phosphoric acid and the prevalence of the disease. Ramsay(54) reports that soils from areas where osteomalacia is prevalent contain less nitrogen, lime, potash, and phosphoric acid than do soils from areas where the disease is uncommon. This writer states that grasses from affected areas contain less phosphoric acid and lime than do grasses from nonaffected areas and that the bones of animals reared in such surroundings contain less lime and phosphoric acid. Jensen(55) found a similar deficiency in soils from sections of New South Wales where the disease is prevalent. Tuff(20) quotes Müller who believes that the cause of osteomalacia is due to a deficiency of phosphoric acid in the fodder. Eckles, Becker, and Palmer(51) produced a mineral deficiency disease of cattle by feeding a ration deficient in phosphorus. Reid(17) states that osteoporosis of horses in India is observed frequently in animals feeding on soils that are deficient in phosphorus. Friedberger and Frohner(5) believe that the cause of the condition is a deficiency of lime in the soil and fodder, and that water which is low in calcium content may assist development of the disease. Hutyra and Marek(12) agree. Van Saceghem(19) reports that, in districts of the Belgian Congo where the water contained little or no calcium, osteoporosis of horses occurred, whereas it never appeared in regions where the natural water contained sufficient calcium. This writer concludes that the cause of the disease is a deficiency of calcium. Niimi(56) and Niimi and Aoki(57) report that they were able to produce typical osteoporosis in horses by feeding a diet deficient in calcium. Control animals on the same diet (barley) to which was added calcium carbonate failed to develop the disease.

Zucker(58) states that Gerhard and Schlesinger studied (1899) the relation of the acid-base equilibrium in the animal body to the calcium and phosphorus metabolism. Ingle(16) in 1907 was the first to suggest the theory that osteoporosis of the Equidæ is favored by the use of foods, not necessarily deficient in lime and phosphates, but in which the ratio of lime and perhaps magnesium, to the phosphoric acid content, is too low. This writer states that the disease itself is caused probably by organisms that develop in animals rendered susceptible by a defective diet. Two years later the same writer(59) stated that, while osteoporosis of horses may be due to a specific organism, a condition of the bones similar to that which results from the disease may be induced by feeding a diet containing a low ratio of lime to phosphorus pentoxide. The statements of Ingle were based on chemical analyses of bones of affected animals as compared with normal bones. He maintains that the ratio of calcium to phosphorus in the feed should be about 1:1, basing this statement on the ratio of these elements in milk.

The numerous investigations of recent years that have been conducted with the view of determining the cause of human rickets have resulted in much evidence supporting the theory that a certain definite ratio between the calcium and the phosphorus intake must be maintained in order to prevent disturbances of mineral metabolism. The experiments of McCollum, Simmonds, Shipley, and Park,(60, 61) Sherman and Pappenheimer,(62) Kramer and Howland,(38) McClendon,(63) Orr, Holt, Wilkins, and Boone,(64) Mellanby and Killick,(65) Karelitz and Shohl,(66, 67) Shohl, Bennett, and Weed,(68) Hess, Weinstock, and Rivkin,(69) Farquharson, Salter, and Aub,(70) and others have added much to the understanding of mineral metabolism and conditions that disturb this process. Practically all investigators now agree that the proportion of calcium to phosphorus in the diet is of prime importance in maintaining normal mineral metabolism of the skeleton. Constant increase in the amounts of either element will so disturb this ratio that harmful effects will result.

Forbes(3) showed that a deficiency of mineral bases in a ration will withdraw mineral matter from the bones. Tuff(20) maintains that for normal mineral metabolism not only sufficient quantities of minerals should be present in the forage but that there should be suitable quantitative proportions between the various minerals and between the acid and basic equivalents in the total fodder. He states that a large surplus of any one mineral or a difference greater than normal between the acid and basic equivalent in the fodder will dissolve minerals from the skeleton. Marek(4) agrees with this view and states that in herbivorous animals, the vegetable food must have a definite surplus of bases as compared with acids if no disturbance is to occur in the mineral metabolism. Of the more-recent work dealing with equine osteomalacia, that of Sturgess(10) deserves consideration. He produced osteomalacia in five horses by feeding diets low in calcium and high in phosphorus. The ratio of calcium oxide to phosphorus pentoxide ranged from 1: 6.5 to 1:18. The control animal of this group received a ration in which the ratio of calcium to phosphorus was 1: 2. This animal, after fourteen months, showed a "slight suspicion of commencing enlargement" of the inferior maxilla. The bone-meal component of the ration was then increased and the disease did not develop. He concluded that osteoporosis occurs when all possibility of infection by contact has been prevented and that, while a slight increase of phosphorus pentoxide (P_2O_5) over the calcium does not produce the disease, horses fed on diets low in calcium and high in phosphorus will develop osteomalacia.

During the present investigation cases of osteomalacia developed in animals which had been maintained on a ration composed of American oats, 3 pounds; crushed palay, 3 pounds; copra meal, 3 pounds; American grain hay, 4.5 pounds; native rice hay, 4.5 pounds; and green fodder, 12.5 pounds. The nutritive ratio of this ration was 1: 7.6. Chemical analysis showed that the intake of calcium oxide was 18.2 grams and of phosphorus pentoxide 53.0 grams, a ratio of 1: 2.9.

The following experiments were planned with a view to determining the influence of vitamin A on the course of osteomalacia and the importance of the ratio between the calcium and the phosphorus intake.

EXPERIMENTAL

In feeding experiment 1, it was found that equine osteomalacia could be arrested by supplementing the ration with vitamins A and D (cod-liver oil). The addition to the ration of vitamin D alone did not influence the progress of the disease. It seemed desirable, therefore, to determine the value of a ration containing products rich in vitamin A. In 1919 Steenbock(71) reported that yellow corn contains fat-soluble vitamin. The discovery that yellow corn is rich in vitamin A was confirmed later by Steenbock and Boutwell,(72) Steenbock and Coward,(73) Meyer and Hetler,(74) Russell,(75) and others. Therefore, yellow corn was added to the ration used in this experiment.

Chemical analysis of the ration on which Army animals in the Philippines were being maintained, showed that the calcium-phosphorus ratio was 1: 2.9. Osteomalacia developed in animals fed on this ration. In feeding experiment 1, the disease progressed in animals fed on a ration that contained calcium oxide and phosphorus pentoxide in the ratio of 1: 2.3 and 1: 2.4. In the following experiment sufficient finely ground limestone was added to the ration to give a calcium-phosphorus ratio of 1:0.9; the ration of the control animal had a ratio of 1:2.5.

Feeding experiment 2.—This was begun January 24, 1931, and continued for a period of three months. The following animals were placed in the feeding group:

Horse 3H70.—Sex, gelding; color, light chestnut; age, 9 years; weight, 860 pounds. Sick record showed a diagnosis of osteomalacia December 15, 1930. January 24, 1931, the animal showed a moderate ridge along the upper border of the mandible and slight enlargement of the facial bones. There was a shortening of the stride. The hair coat and general condition were fair. The serum calcium was 10.9 milligrams; and the inorganic phosphorus, 3.85 milligrams. X-ray examination of the metacarpal bone showed a moderate rarefaction of the compact portion.

Horse 76C3.—Sex, gelding; color, bay; age, 11 years; weight, 885 pounds. Clinical examination of this animal showed a slight thickening of the rami of the mandible. Slight shortening of the stride was present. The hair coat and general condition were fair. The serum calcium was 10.6 milligrams; and the inorganic phosphorus, 3.85 milligrams. X-ray examination showed a marked rarefaction of the cortex of the metacarpal bone. This case represents a type of osteomalacia that shows only slight symptoms on clinical examination but advanced changes in the bone (Plate 7, fig. 1).

Horse 38V0.—Sex, mare; color, bay; age, 4 years; weight, 760 pounds. The sick record showed a diagnosis of osteomalacia November 14, 1930. Moderate proliferative changes of the mandible and facial bones were present. Lordosis was present. The stride was shortened moderately. The general condition was fair, and the hair coat was good. The serum calcium was 11.1 milligrams; and the inorganic phosphorus, 4.76. X-ray examination showed a very slight rarefaction of the metacarpal bone.

Horse H463.—Sex, gelding; color, bay; age, 16 years; weight, 800 pounds. Sick record listed osteomalacia as a diagnosis January 6, 1931. Clinical examination January 24, 1931, elicited a moderate proliferation along the upper border of the mandible. Facial enlargement was absent. The stride was shortened. A moderate lordosis was present. The serum calcium was 11.3 milligrams; and the inorganic phosphorus, 3.57. X-ray examination showed a moderate rarefaction of the metacarpal bone.

Horse 1B11.—Sex, mare; color, dark bay; age, 12 years; weight, 820 pounds. Sick record gave a diagnosis of osteomalacia November 4, 1930. The animal was returned to duty November 22 and readmitted to sick report December 29, 1930, with a diagnosis of osteomalacia. January 24, 1931, the animal exhibited a moderate ridge along the superior border of the mandible. There was no facial enlargement. The stride was shortened moderately. The general condition was poor, and the hair coat fair. The serum calcium was 10.9 milligrams; and the inorganic phosphorus, 4.56. X-ray examination showed a slight rarefaction of the compact portion of the metacarpal bone.

Horse 13L2.—Sex, gelding; color, bay; age, 8 years; weight, 810 pounds. This animal was admitted to sick report with a diagnosis of osteomalacia (suspect) August 29, 1930, and returned to duty September 26, 1930. November 14, 1930, the animal was admitted to the veterinary hospital with a diagnosis of osteomalacia and returned to duty November 21, 1930. December 29, 1930, the animal was readmitted to the hospital with a diagnosis of osteomalacia. Clinical examination January 24, 1931, showed that the animal had a marked proliferation of bony tissue along the superior border of the rami of the mandible. There was a slight enlargement of the facial bones. The shoulders appeared to be displaced forward and there was a "tucked-up" appearance to the flank. The gait was shortened slightly. The hair coat was good, and the general condition fair. The serum calcium was 10.1 milligrams; and the inorganic phosphorus, 4.76. X-ray examination showed a slight rarefaction of the cortical portion of the metacarpal bone.

Horse C442.—This animal was used in feeding experiment 1, and the description of the animal together with the sick record has been given thereunder (Plates 3 and 4 and fig. 7). Clinical examination January 24, 1931, showed marked proliferative changes in the mandible and the facial bones. There was a marked prominence of the shoulder joints and a slight lordosis (Plate 3). The stride was shortened markedly, and there was a moderate "tucked-up" appearance to the flank. The general condition was poor and the hair coat fair in appearance. The serum calcium was 9.2 milligrams; and the inorganic phosphorus, 5.26. X-ray examination showed a marked rarefaction of the compact portion of the metacarpal bone (Plate 4, fig. 2).

Horse 09V2.—Sex, gelding; color, bay; age, 20 years; weight, 750 pounds. Sick record of this animal showed an admission for osteomalacia June 20, 1930. The animal was returned to duty and readmitted for osteomalacia November 21, 1930. Clinical symptoms January 24, 1931, showed a marked change along the upper border of the rami of the mandible. No facial enlargement was present. A slight lordosis existed. The stride of the front legs was markedly shortened, and a moderate shortening was present in the hind legs. The general condition was fair, and the hair coat was of good appearance. The serum calcium was 11.8 milligrams; and the inorganic phosphorus, 3.9. X-ray examination showed a marked rarefaction of the compact portion of the metacarpal bone (Plate 8, fig. 1).

Horse 74B9.—This animal was used in feeding experiment 1, and the description of the animal and sick report have been given thereunder (fig. 7). Clinical examination January 24, 1931, showed marked proliferative changes in the mandible and the facial bones. The stride was shortened moderately in front. The general condition and hair coat were good. The serum calcium was 11.0 milligrams; and the inorganic phosphorus, 4.56. X-ray examination showed a moderate rarefaction of the metacarpal bone (Plate 6, fig. 2).

Horse 1B19.—Sex, gelding; color, bay; age, 12 years; weight, 740 pounds. The sick record of this animal showed an admission to hospital July 29, 1930, with a diagnosis of chronic gastroenteritis. September 1, 1930, malnutrition is recorded as a complication, and October 3, 1930, the entry of osteomalacia suspect was made. December 3, 1930, the diagnosis of osteomalacia was recorded. Clinically, January 24, 1931, the animal showed a slight enlargement of the mandible and slight lordosis. The stride was modified slightly. The flank showed the characteristic "tucked-up" appearance. The general condition and hair coat were good. The serum calcium was 10.7 milligrams; and the inorganic phosphorus 3.33. X-ray examination showed a slight rarefaction of the metacarpal bone.

Animals 3H70, 76C3, 38V0, H463, 1B11, 13L2, C442, 09V2, and 74B9 were fed a ration composed of oats, 2 pounds; yellow corn (cracked), 2 pounds; palay (crushed), 1⅓ pounds; copra meal, ⅔ pound; limestone (finely ground), 2.5 ounces; American grain hay, 4.5 pounds; native rice hay, 4.5 pounds; and fresh green grass, 12.5 pounds. The nutritive ratio of this ration was 1 : 9. The calcium oxide intake was 49 grams and the phosphorus pentoxide, 42 grams, a ratio of 1 : 0.9.

Horse 1B19 was added to the feeding group as a control and received a ration composed of oats, 2 pounds; palay (crushed), 2 pounds; copra meal, 2 pounds; American grain hay, 4.5 pounds; native rice hay, 4.5 pounds; and fresh green grass, 12.5 pounds. The nutritive ratio of this ration was 1 : 8. The intake of calcium oxide was 17 grams and of phosphorus pentoxide, 43 grams, a ratio of 1 : 2.5.

During the day all animals of the group were kept in a large corral where drinking water was available at all times. Chemical analysis of this water showed a calcium content of 19.5 parts per million.

Fig. 8 shows the progress of the disease in all animals of this group. It will be noted, by reference to fig. 8, that all animals of the group showed improvement except the control animal (1B19). Five of the nine animals on the test ration were returned to light duty, while one animal (74B9) was returned to full duty. The disease showed definite progression in the control animal (1B19). Plate 7, figs. 1 and 2, shows the change that took place in the metacarpal bone of horse 76C3. Plate 8, fig. 1 shows the metacarpal bone of horse 09V2 January 24, 1931, and Plate 8, fig. 2, April 24, 1931.

Animal Number	Date	Physical Examination						Blood Chemistry Milligrams per 100 cc serum		X Ray Examination	Remarks
		Weight (Lbs.)	Head Lesions		Gait		General Condition				
			Mandible	Facial	Front	Rear		Calcium	Inorganic Phosphorus		
3H70	1931 Jan. 24	860	●●	●	●●	●●●	▲▲	10.9	3.85	●●	
	April 24	880	●●	●	●●	●●	■	11.8	4.00	●	
76C3	Jan. 24	885	●			●	▲▲	10.6	3.85	●●●	
	April 24	910	●			●	■	12.2	3.45	●●	Light duty
38V0	Jan. 24	760	●●	●●		●●	▲▲	11.1	4.76	●	
	April 24	810	●●	●●●			■	13.0	3.87	Normal	Light duty
H463	Jan. 24	800	●●		●	●	▲▲	11.3	3.57	●●	
	April 24	870	●●			●	■	10.8	3.87	●	Light duty
1B11	Jan. 24	820	●●		●●	●●	■■■	10.9	4.56	●	
	April 24	880	●●		●		■	12.9	3.87	● (Improved)	Light duty
13L2	Jan. 24	810	●●●	●	●	●	▲▲	10.1	4.76	●	
	April 24	880	●●	●			■	14.6	3.13	Normal	Light duty
C442	Jan. 24	850	●●●	●●●	●●●	●●●	■■■	9.2	5.26	●●●	
	April 24	850	●●●	●●	●●	●●	▲▲	9.8	4.00	●	
09V2	Jan. 24	750	●●●		●●●	●●	▲▲	11.8	3.94	●●●	
	April 24	770	●●		●		▲	11.0	4.00	●	
74B9	Jan. 24	960	●●●	●●●	●●		■■	11.0	4.56	●●	
	April 24	930	●●●	●●●			■	12.7	3.87	●●	Full duty
1B19 (Control)	Jan. 24	740	●			●	■■	10.7	3.33	●	
	April 24	790	●●		●	●	▲	12.5	3.13	●●	

●	Slight or mild
●●	Moderate
●●●	Marked or severe
■	Excellent
▲	Very good
■■	Good
▲▲	Fair
■■■	Poor

Test Ration	
Oats	2 lbs.
Yellow corn	2 lbs.
Palay	1⅓ lbs.
Copra meal	⅔ lbs.
Limestone (finely ground)	2½ oz.
American grain hay	4½ lbs.
Rice hay	4½ lbs.
Green grass	12½ lbs.

Control Ration	
Oats	2 lbs.
Palay	2 lbs.
Copra meal	2 lbs.
American grain hay	4½ lbs.
Rice hay	4½ lbs.
Green grass	12½ lbs.

Fig. 8. Feeding experiment 2.

At the beginning of the experiment, the average serum calcium for all animals fed on the test ration was 10.8 milligrams and the inorganic phosphorus 4.35 milligrams per 100 cubic centimeters. These values at the end of the experiment were 12.1 and 3.78 milligrams, respectively, an increase of 12 per cent in serum calcium and a decrease of 10.8 per cent in inorganic phosphorus. It will be noted in the section on chemical pathology that a low serum calcium and a high serum inorganic phosphorus are present in osteomalacia.

Comment.—1. Nine horses, affected with osteomalacia and maintained for ninety days on a ration to which yellow corn and limestone had been added, showed definite improvement clinically, and X-ray examination of the metacarpal bones showed that the disease had been arrested and an increased deposition of minerals had taken place. The mineral ratio of the ration was calcium oxide 1 to phosphorus pentoxide 0.9.

2. Changes in the serum calcium and inorganic phosphorus indicated that improvement of the condition had taken place.

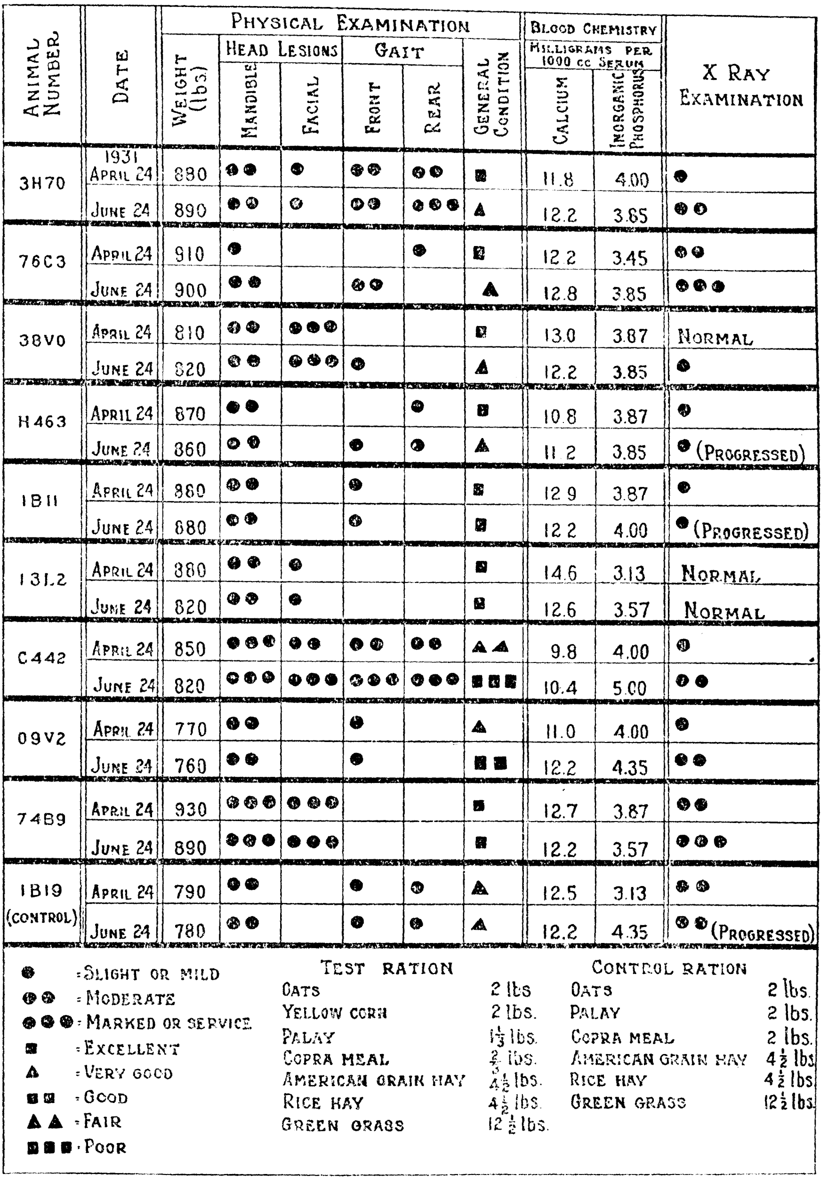
3. One control animal maintained on a ration having a ratio of calcium oxide to phosphorus pentoxide of 1:2.5 showed no clinical improvement. X-ray examination showed progressive rarefaction of the bone.

Feeding experiment 3.—This experiment was started April 24, 1931, and continued for a period of sixty days. The animals composing the group were the same as in feeding experiment 2, and the ration the same with the exception that the limestone was omitted in the present experiment. The nutritive ratio remained unchanged, but the intake of calcium oxide was 14.2 grams (instead of 49 grams) and of phosphorus pentoxide, 42 grams, a ratio of approximately 1 : 3 (instead of 1 : 0.9). Control animal 1B19 received a ration having a ratio of calcium oxide to phosphorus pentoxide of 1 : 2.5.

As shown in fig. 9, the disease progressed in eight of the nine animals. The average serum calcium for the group remained approximately the same. The inorganic phosphorus increased about 6 per cent.

Comment.—A ration composed of oats, yellow corn, crushed palay, copra meal, American grain hay, native rice hay, and green fodder failed to arrest equine osteomalacia. On the other hand the condition progressed in eight of the nine animals on test. The calcium-phosphorus ratio was 1 : 3, approximately.

The condition progressed in the control animal, which was fed a ration containing calcium and phosphorus in the ratio of 1 : 2.5.



Animal Number	Date	Physical Examination						Blood Chemistry Milligrams per 1000 cc Serum		X Ray Examination
		Weight (lbs.)	Head Lesions		Gait		General Condition			
			Mandible	Facial	Front	Rear		Calcium	Inorganic Phosphorus	
3H70	1931 April 24	880	●●	●	●●	●●	■	11.8	4.00	●
	June 24	890	●●	●	●●	●●●	▲	12.2	3.85	●●
76C3	April 24	910	●			●	■	12.2	3.45	●●
	June 24	900	●●		●●		▲	12.8	3.85	●●●
38V0	April 24	810	●●	●●●			■	13.0	3.87	Normal
	June 24	820	●●	●●●	●		▲	12.2	3.85	●
H463	April 24	870	●●			●	■	10.8	3.87	●
	June 24	860	●●		●	●	▲	11.2	3.85	● (Progressed)
1B11	April 24	880	●●		●		■	12.9	3.87	●
	June 24	880	●●		●		■	12.2	4.00	● (Progressed)
13L2	April 24	880	●●	●			■	14.6	3.13	Normal
	June 24	820	●●	●			■	12.6	3.57	Normal
C442	April 24	850	●●●	●●	●●	●●	▲▲	9.8	4.00	●
	June 24	820	●●●	●●●	●●●	●●●	■■■	10.4	5.00	●●
09V2	April 24	770	●●		●		▲	11.0	4.00	●
	June 24	760	●●		●		■■	12.2	4.35	●●
74B9	April 24	930	●●●	●●●			■	12.7	3.87	●●
	June 24	890	●●●	●●●			■	12.2	3.57	●●●
1B19 (Control)	April 24	790	●●		●	●	▲	12.5	3.13	●●
	June 24	780	●●		●	●	▲	12.2	4.35	●● (Progressed)

● = Slight or mild
●● = Moderate
●●● = Marked or service
■ = Excellent
▲ = Very good
■■ = Good
▲▲ = Fair
■■■ = Poor

Test Ration	
Oats	2 lbs
Yellow corn	2 lbs.
Palay	1⅓ lbs.
Copra meal	⅔ lbs.
American grain hay	4½ lbs.
Rice hay	4½ lbs.
Green grass	12½ lbs.

Control Ration	
Oats	2 lbs.
Palay	2 lbs.
Copra meal	2 lbs.
American grain hay	4½ lbs.
Rice hay	4½ lbs.
Green grass	12½ lbs.

FIG. 9. Feeding experiment 3.

Feeding experiment 4.—This experiment was started July 22, 1931, and continued for a period of ninety-eight days. The animals were placed in three groups of five each as follows:

Group A.

Horse 76C3.—This animal had been used in feeding experiments 2 and 3. Clinically, it showed a moderate thickening of the rami of the mandible. There was a moderate shortening of the stride. The serum calcium was 11.3 milligrams; and the inorganic phosphorus, 4.35 milligrams. The general condition was very good. X-ray examination of the metacarpal bone showed a marked rarefaction of the cortex.

Horse O9V2.—This animal had been used in the two previous feeding experiments. Clinically, it showed moderate proliferative changes of the mandible. The stride was shortened slightly, and the general condition was good. The serum calcium was 12.0 milligrams; and the inorganic phosphorus, 4.76 milligrams. X-ray examination of the metacarpal bone showed a rarefaction of moderate degree.

Horse H463.—This animal had been used in feeding experiments 2 and 3. Examination showed a slight thickening of the rami of the mandible. There was a slight shortening of the stride. The general condition was very good. The serum calcium was 11.5 milligrams; and the inorganic phosphorus, 4.7 milligrams. The metacarpal bone showed a slight rarefaction on X-ray examination.

Horse 1B11.—This animal had been used in feeding experiments 2 and 3. Clinically, there was a moderate proliferative change of the mandible. The stride was shortened slightly, and the general condition was excellent. The serum calcium was 11.6 milligrams; and the inorganic phosphorus, 4.0 milligrams. X-ray examination of the metacarpal showed a slight rarefaction of the cortex.

Horse OC35.—Sex, gelding; color, brown; age, 10 years; weight, 820 pounds. Sick record showed that this animal had been admitted to the veterinary hospital at Fort Stotsenburg December 13, 1930, with a diagnosis of ringbone, right foreleg. The animal remained in the hospital until December 23, 1930, when it was returned to duty. January 30, 1931, a diagnosis of osteomalacia was made. When examined July 22, 1931, the animal showed a moderate enlargement of the mandible and a slightly shortened stride. The general condition was good. The serum calcium was 11.3 milligrams; and the inorganic phosphorus, 4.7 milligrams. X-ray examination showed a slight rarefaction of the metacarpal bone.

Group B.

Horse B776.—This animal had been used in feeding experiment 1. Clinically, there was manifested a marked thickening of the rami of the mandible and slight proliferative changes of the maxillæ. The stride was shortened markedly, and the general condition was fair. The serum calcium was 10.6 milligrams; and the inorganic phosphorus, 4.76 milligrams. X-ray examination of the metacarpal bone showed a marked rarefaction (Plate 9, fig. 1).

Horse 249C.—This animal had been used previously in feeding experiment 1. Clinically, it showed a moderate enlargement of the rami of the mandible and a moderately shortened stride. The general condition was fair. The serum calcium was 10.5 milligrams; and the inorganic phosphorus, 4.0 milligrams. X-ray examination showed a marked rarefaction of the metacarpal bone.

Horse C442.—This animal had been used previously in feeding experiments 1, 2, and 3. There was a marked enlargement of the rami of the mandible and marked proliferative changes of the facial bones. The stride was shortened markedly, and the general condition was poor. The serum calcium was 10.0 milligrams; and the inorganic phosphorus, 4.35 milligrams. X-ray examination showed a marked rarefaction of the metacarpal bone.

Horse 1B19.—This animal had been used in feeding experiments 2 and 3. July 22, 1931, it showed a moderate enlargement of the rami of the mandible and a slightly shortened stride. The general condition was very good. The serum calcium was 12.5 milligrams; and the inorganic phosphorus, 5.0 milligrams. X-ray examination of the metacarpal bone showed a moderate rarefaction of the cortical portion.

Mule B059.—Sex, gelding; color, gray; age, 11 years; weight 950 pounds. The sick record of this animal showed a diagnosis of osteomalacia May 7, 1391. Clinically, there was a moderate proliferative change along the rami of the mandible and a shortening of the stride. The general condition was very good. The serum calcium was 11.0 milligrams; and the inorganic phosphorus, 4.17 milligrams. X-ray examination showed a slight rarefaction of the metacarpal bone.

Group C.

Mule H223.—Sex, mare; color, brown; age, 7 years; weight, 970 pounds. The sick record showed a diagnosis of osteomalacia March 13, 1931. The animal had continued on a duty status until admitted to the hospital for this condition April 9, 1931. The record shows hospital treatment from April 9 to June 24, 1931, when the animal was transferred to Manila for experimental purposes. There was present a slight ridge along the upper border of the rami of the mandible and slight proliferative changes of the facial bones. The stride was shortened slightly, and the general condition was very good. The serum calcium was 12.0 milligrams; and the inorganic phosphorus, 4.76. X-ray examination of the metacarpal bone showed a slight rarefaction of the cortical portion.

Horse 3H70.—This animal had been used previously in feeding experiments 2 and 3. Moderate proliferative changes along the upper border of the mandible and slight enlargement of the facial bones were present. The stride was shortened, and the general condition was very good. The serum calcium was 12.4 milligrams; and the inorganic phosphorus, 5.0. X-ray examination showed moderate rarefaction of the metacarpal bone.

Horse L698.—Sex, mare; color, chestnut; age, 12 years; weight, 780 pounds. The sick record showed an admission to the veterinary hospital at Fort Stotsenburg January 29, 1931, with a diagnosis of osteomalacia. The animal was returned to duty February 28, 1931, readmitted for osteomalacia June 8, 1931, and transferred to Manila June 24, 1931. Clinical examination showed marked proliferative changes along the superior border of the rami of the mandible and a moderate shortening of the stride. The general condition was good. The serum calcium was 11.8 milligrams; and the inorganic phosphorus, 4.0. X-ray examination showed a slight rarefaction of the cortex of the metacarpal bone.

Horse 278L.—Sex, mare; color, brown; age, 8 years; weight, 800 pounds. The sick record showed a diagnosis of osteomalacia January 28, 1931, the animal being marked off duty January 31, 1931. March 21, 1931, the animal was admitted to the hospital with the same diagnosis and continued in that status until transferred to Manila for experimental purposes June 24, 1931. Clinically, the animal showed moderate proliferative changes along the superior border of the rami of the mandible and slight enlargement of the facial bones. The stride was shortened markedly, and the general condition was good. The serum calcium was 10.8 milligrams; and the inorganic phosphorus, 4.35. X-ray examination showed a slight rarefaction of the metacarpal bone.

Horse 5B42.—Sex, mare; color, chestnut; age, 11 years; weight, 840 pounds. A diagnosis of osteomalacia was recorded in May, 1931. Examination July 22, 1931, showed slight proliferative changes along the upper border of the rami of the mandible. The stride was shortened moderately, and the general condition was fair. The serum calcium was 11.8 milligrams; and the inorganic phosphorus, 4.17. X-ray examination showed a moderate rarefaction of the cortical portion of the metacarpal bone.

RATION

Group A.

The animals of this group (76C3, O9V2, H463, 1B11, and OC35) were fed a ration composed of oats, 3 pounds; crushed palay, 3 pounds; copra meal, 2 pounds; American grain hay, 4.5 pounds; native rice hay, 4.5 pounds; and green grass, 12.5 pounds. The nutritive ratio was 1 : 8.7. A sufficient amount of commercial calcium chloride was added to the drinking water to increase the calcium content to approximately 400 parts per million. During an observation period of ten days it was found that these animals would drink approximately 6.5 gallons of water daily. The total mineral intake was calcium oxide 32 grams and phosphorus pentoxide 48 grams, a ratio of calcium to phosphorus of 1 : 1.5. August 6 it was noted that the animals of this group were not consuming their entire allowance of 8 pounds of concentrates. This allowance was then reduced to 6 pounds, resulting in a nutritive ratio of 1 : 8.3 and a mineral intake of calcium oxide of 31.6 grams and phosphorus pentoxide 43 grams, a ratio of calcium to phosphorus of 1 : 1.4. All animals of the group were exercised from one to two hours daily during the test period.

Group B.

The animals of this group (B776, 249C, C442, 1B19, and B059) were fed a ration composed of oats, 1.5 pounds; crushed palay, 1.5 pounds; copra meal, 1 pound; American grain hay, 4.5 pounds; native rice hay, 4.5 pounds; and green grass, 12.5 pounds. Each animal received 36 grams of finely ground limestone daily, the analysis of which showed 46.56 per cent calcium calculated as the oxide. The calcium content of the drinking water was 19.5 parts per million. The nutritive ratio of this ration was 1 : 8.7. The total mineral intake was calcium oxide 34 grams and phosphorus pentoxide 36 grams, a ratio of approximately 1 : 1. The animals of this group were kept in a large corral during the day and stabled at night. No exercise was given.

Group C.

The animals of this group (H223, 3H70, L698, 278L, and 5B42) were fed the same ration as were the animals of group B with the exception that each animal received 0.5 pound of wheat bran daily, and 100 grams calcium phosphate was substituted for the finely ground limestone (calcium carbonate). The nutritive ratio remained approximately the same (1 : 8.5). The calcium oxide intake was the same as in group B (34 grams) and the phosphorus pentoxide 85 grams, a ratio of 1 : 2.5. Animals of this group were kept in a large corral during the day and stabled at night; no forced exercise was given.

The progress of the disease in the above groups of animals is shown in fig. 10. It will be noted, by reference to fig. 10, that all animals of group A showed improvement. The X-ray examination showed that the condition had been arrested, and there was evidence that repair of the bone was taking place. The average serum calcium at the beginning of the experiment was 11.5 milligrams; and the inorganic phosphorus, 4.5 milligrams. At the completion of the experiment the animals of this group showed an increase of 11 per cent in the serum calcium and a decrease of 18 per cent in the inorganic phosphorus. It has been found, as shown under the section on chemical pathology, that in active equine osteomalacia the serum calcium is reduced and the inorganic phosphorus is increased. The intake ratio of calcium oxide to phosphorus pentoxide was 1 : 1.4.

The calcium intake of animals of groups B and C was approximately the same (34 grams). The addition of ground limestone to group B animals resulted in a calcium-phosphorus ratio of 1 : 1, and the addition of calcium phosphate to the ration of group C animals gave a ratio of 1 : 2.5. It will be noted, by reference to fig. 10, that all animals of group B showed definite improvement while three of the five animals of group C showed that the disease was progressing. The serum calcium of the animals of group B was increased 16 per cent, and the inorganic phosphorus was decreased 31 per cent. The averages for serum calcium and inorganic phosphorus of the animals of group C was approximately the same at the completion of the experiment as at the beginning.

Comment.—Osteomalacia was arrested and the condition showed evidence of healing in all cases(5) fed on a ration in which the calcium-phosphorus ratio was 1 : 1.4.

Two groups of five cases each were fed rations containing the same amounts of calcium but different quantities of phosphorus. All animals of the group receiving a ration in which the calcium-phosphorus ratio was 1 : 1 showed definite improvement. The other group was fed a ration in which the calcium-phosphorus ratio was 1 : 2.5, which was produced as a result of the use of calcium phosphate instead of calcium carbonate. In three of the five animals of this group, definite progression of the disease was noted.

Animal Number	Date	Physical Examination						Blood Chemistry		X Ray Examination
		Weight (Lbs.)	Head Lesions		Gait		General Condition	Milligrams per 100 cc serum		
			Mandible	Facial	Front	Rear		Calcium	Inorganic Phosphorus	
Ration "A"										
76C3	1931 July 22	890	●●		●●		▲	11.3	4.35	●●●
	Oct. 28	880	●●		●	●	▲	11.5	3.57	●●●(Improved)
09V2	July 22	750	●●		●	●	■■	12.0	4.76	●●
	Oct. 28	730	●		●	●	■■	12.9	3.85	●
H463	July 22	850	●		●	●	▲	11.5	4.70	●
	Oct. 28	860	●		●	●	▲	13.1	4.00	● (Improved)
1B11	July 22	900	●●		●		■	11.6	4.00	●
	Oct. 28	900	●		●		■	13.1	3.57	●(Slightly Improved)
0C35	July 22	820	●●		●		■■	11.3	4.70	●
	Oct. 28	810	●				■	13.4	3.70	● (Improved)
Ration "B"										
B776	July 22	720	●●●	●	●●●	●●●	▲▲	10.6	4.76	●●●
	Oct. 28	740	●●	●	●●●	●●	▲▲	13.4	3.33	●●
249C	July 22	1090	●●		●●	●●	▲▲	10.5	4.00	●●●
	Oct. 28	1110	●●		●	●	■■	13.1	2.86	●●●(Improved)
C442	July 22	810	●●●	●●●	●●	●●●	■■■	10.0	4.35	●●●
	Oct. 28	820	●●●	●●	●●	●●	▲▲	11.7	3.03	●●
1B19	July 22	770	●●		●	●	▲	12.5	5.00	●●
	Oct. 28	790	●				▲	14.0	3.49	●●(Improved)
B059	July 22	950	●●		●	●●●	▲	11.0	4.17	●
	Oct. 28	980	●●		●	●●	■	12.5	2.78	● (Improved)
Ration "C"										
H223	July 22	970	●	●	●	●	▲	12.0	4.76	●
	Oct. 28	980	●	●		●	▲	12.3	4.00	●
3H70	July 22	910	●●	●	●	●●	▲	12.4	5.00	●●
	Oct. 28	920	●●	●	●●	●●	▲	12.8	4.76	●●(Progressed)
L698	July 22	780	●●●		●●	●●	■■	11.8	4.00	●
	Oct. 28	770	●●●		●●	●●	▲▲	12.1	4.70	●
278L	July 22	800	●●	●	●●●	●●●	■■	10.8	4.35	●
	Oct. 28	790	●●	●	●●	●●●	■■	12.0	4.00	●●
5B42	July 22	840	●		●●	●●	▲▲	11.8	4.17	●
	Oct. 28	810	●●		●●●	●●●	■■	10.2	5.00	●●

● = Slight or mild
●● = Moderate
●●● = Marked or severe
■ = Excellent
▲ = Very good
■■ = Good
▲▲ = Fair
■■■ = Poor

Fig. 10. Feeding experiment 4.

Feeding experiment 5.—Out of a shipment of animals arriving in the Philippines from the United States in July, 1930, thirty-one horses were shipped to Fort Stotsenburg where they were fed the regular ration for Army animals. This ration was oats, 3 pounds; crushed palay, 3 pounds; copra meal, 3 pounds; American grain hay, 4.5 pounds; native rice hay, 4.5 pounds; and native green grass, 12.5 pounds. The nutritive ratio was 1 : 7.3. The drinking water supplied these animals contained 9.7 parts of calcium per million. The total intake of calcium oxide per animal was 18.5 grams, and the phosphorus pentoxide, 53 grams, a ratio of 1: 2.9.

Twenty-five horses from the above-mentioned shipment were kept at Nichols Field and fed a ration of American oats, 9 pounds, and American grain hay, 14 pounds. The nutritive ratio was 1 : 7.6. The drinking water at this station contained 33 parts of calcium per million. The total calcium oxide intake was 15.7 grams, and the phosphorus pentoxide intake was 29.1 grams, a ratio of 1 : 1.9. The total mineral intake in all cases was based on the mineral content of the ration plus the minerals contained in 6.5 gallons of water, the latter being the average amount consumed by each animal daily. All animals were of the riding type and their ages ranged from 4 to 7 years. Several days after their arrival in Manila, complete physical examinations were made and the serum calcium and inorganic phosphorus determined. No evidence of osteomalacia was found. Both groups were examined at frequent intervals during the next nine months. The serum calcium and inorganic phosphorus determinations were made after a period of approximately six months.

Veterinary hospital records at Fort Stotsenburg show that three, approximately 10 per cent, of the thirty-one animals shipped to that station developed osteomalacia within nine months. The first case occurred in March, 1931, in an 8-year-old bay mare. This animal was destroyed in June, 1931, after hospitalization for ninety-one days. The second case occurred in a 5-year-old bay mare and was diagnosed April 16, 1931. This animal was not hospitalized and continued on a duty status. The third animal of this group that developed the condition was a 6-year-old bay mare. This case was diagnosed osteomalacia May 11, 1931, and was returned to duty after eighteen days in the hospital.

Frequent clinical examinations of the twenty-five animals kept at Nichols Field failed to demonstrate the presence of osteomalacia in this group.

As previously stated, serum calcium and inorganic phosphorus determinations were made on all animals of each group at the time of their arrival in the Philippines, and again approximately six months later. Table 9 shows the serum calcium and inorganic phosphorus values in animals of each group at the time of arrival in the Philippines and six months later.

It will be noted that very little change had taken place in the serum calcium and the inorganic phosphorus of the animals fed a ration in which the calcium oxide-phosphorus pentoxide ratio was 1 : 1.9, whereas the group of animals maintained on a ration in which this ratio was 1 : 2.9 showed a decrease of approximately 5 per cent in the serum calcium and an increase of approximately 20 per cent in the inorganic phosphorus. The writers have found that the serum calcium is decreased and the inorganic phosphorus is increased in groups of animals showing osteomalacia. Fig. 11 shows graphically the changes noted.

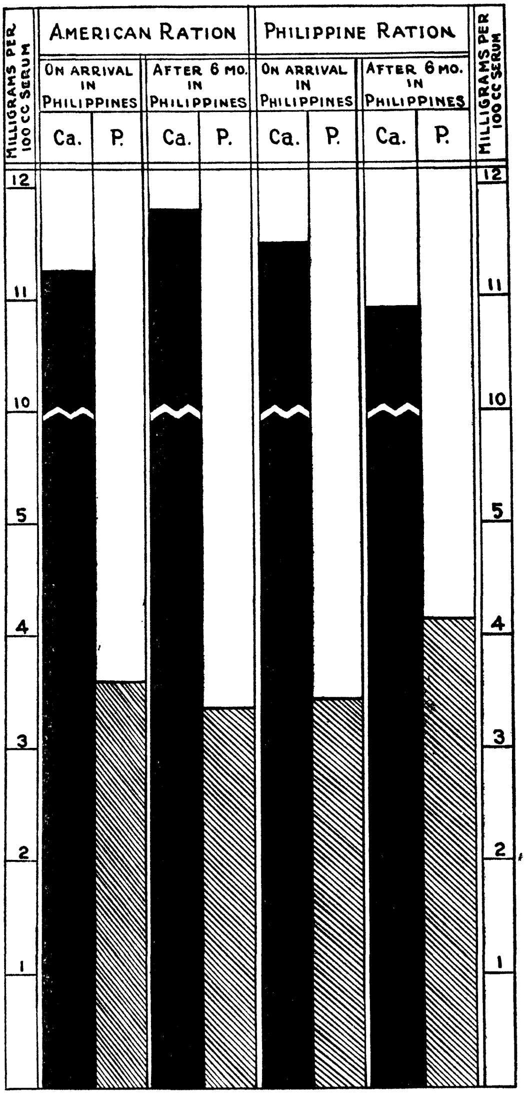


FIG. 11. Comparison of American and Philippine rations.

Comment.—In this feeding experiment, approximately 10 per cent of a group of thirty-one animals fed on a ration in which the calcium-phosphorus intake ratio was 1:2.9 developed clinical osteomalacia within nine months.

A reduced serum calcium and an increased inorganic phosphorus were present in this group.

No evidence of osteomalacia was found in a group of twenty-five horses whose calcium-phosphorus intake ratio was 1:1.9. No blood changes indicative of osteomalacia were evident in this group.

EPIZOÖLOGICAL STUDY

In conjunction with the etiology of osteomalacia, certain pertinent facts were evident in an epizoölogical study, details of which are given elsewhere in this article. Prior to 1923, all Army animals in the Philippines were fed a

TABLE 9.—*Calcium and phosphorus content of serum of American horses in the Philippine Islands.*

American ration.					Philippine ration.				
Animal No.	Milligrams per 100 cc serum.				Animal No.	Milligrams per 100 cc serum.			
	On arrival in P. I.		After 6 mo. in P. I.			On arrival in P. I.		After 6 mo. in P. I.	
	Calcium.	Inorganic phosphorus.	Calcium.	Inorganic phosphorus.		Calcium.	Inorganic phosphorus.	Calcium.	Inorganic phosphorus.
5	10.5	3.23	11.5	3.33	1	10.3	2.94	10.8	4.00
8	11.1	3.33	13.2	3.23	2	11.6	3.45	11.6	4.56
9	12.8	3.70	11.1	3.33	3	12.1	3.33	11.0	4.76
10	12.3	3.85	11.2	4.00	4	11.5	2.94	10.8	5.00
17	10.5	3.70	12.2	3.57	6	12.3	3.57	11.4	4.17
19	11.1	3.70	13.4	3.13	11	13.2	3.33	11.5	4.00
21	10.2	3.85	12.2	3.57	13	13.5	3.23	10.2	4.35
28	11.7	4.35	12.2	3.45	14	13.7	3.85	11.2	3.85
29	12.1	4.00	11.7	3.85	15	14.0	3.13	10.6	4.00
32	10.6	3.70	11.5	2.86	20	11.3	3.03	12.3	4.00
33	11.7	3.33	11.2	3.13	23	11.3	3.33	10.8	4.76
34	12.6	3.85	11.5	3.13	26	10.9	4.00	10.6	4.35
35	11.2	5.00	11.3	3.70	27	11.8	3.70	10.6	3.85
37	11.6	3.57	11.9	3.33	31	10.2	2.63	10.2	3.70
39	10.5	3.85	11.9	3.13	36	11.0	3.33	11.2	4.76
41	11.9	3.13	11.6	3.85	42	10.6	3.57	10.2	4.35
44	10.5	3.13	11.4	3.23	43	10.8	3.85	10.8	3.70
48	10.2	3.13	11.2	3.45	45	11.2	3.13	10.4	4.00
54	11.0	3.85	11.7	3.45	47	12.9	3.13	9.8	4.00
55	10.6	3.45	11.2	3.13	49	10.2	3.85	11.2	4.00
59	11.0	3.13	12.6	3.23	50	10.2	4.56	11.2	4.17
60	11.2	3.03	11.2	3.33	51	10.9	4.00	10.2	4.00
65	13.0	3.85	11.7	3.33	52	10.6	3.85	10.8	3.33
67	11.4	3.13	11.3	3.13	53	10.2	3.45	10.6	4.00
69	10.9	3.33	12.4	3.57	57	10.8	3.13	12.6	3.33
					58	10.9	3.85	11.7	3.70
					61	11.0	3.03	11.2	3.85
					62	11.2	3.13	11.0	4.55
					63	11.1	3.13	10.6	3.45
					64	11.1	3.13	10.8	4.55
					68	12.7	3.33	10.8	4.76
Average	11.3	3.61	11.8	3.34	Average	11.5	3.42	10.9	4.12

ration composed of oats and American grain hay. Available records for this period fail to show the presence of osteomalacia, and the incidence rate for diseases of the bones and organs of locomotion approximates the rate for Army animals in the United States. While available data do not show the calcium and phosphorus intake at that time, recent analyses indicate a calcium-phosphorus ratio of approximately 1: 1.9.

In 1923 when the ration was changed to oats, crushed palay, copra meal, American grain hay, native rice hay, and green grass, the calcium-phosphorus ratio that resulted was approximately 1 : 2.9. Following this change of ration the incidence rate for diseases of the bones and of the organs of locomotion showed a sharp increase.

From 1923 to July, 1931, all Army animals in the Philippines received approximately the same ration. Study of the available records of animal conditions at the larger Army posts for the period July 1, 1930, to July 1, 1931, showed that there was a striking difference between the osteomalacia rates at several of the posts. The fact that the ration at all posts was identical led the writers to investigate the composition of the drinking water supplied. Chemical analyses showed a wide variation in the calcium content of the water at the different posts (see Table 20). It was found that osteomalacia did not occur at Fort Mills (Corregidor) where approximately one hundred animals were kept. The drinking water at this post showed the highest calcium content of any post in the Philippines; namely, 125 parts per million. Based on an average daily consumption of 6.5 gallons of water per animal and the ration fed, the calcium oxide-phosphorus pentoxide intake ratio was 1 : 2.3. At Fort Stotsenburg the water contained the lowest calcium content (9.7 parts per million) and the records show the highest incidence of osteomalacia. Based on the same amount of water consumed daily and the same ration, the calcium oxide-phosphorus pentoxide intake ratio of animals at Fort Stotsenburg was 1 : 2.9.

Further evidence that the cause of osteomalacia in the present investigation was due to a wide calcium-phosphorus ratio is shown by the striking reduction in the number of cases that occurred at Fort Stotsenburg following a change of ration in July, 1931, when finely ground limestone was added to the ration and the calcium-phosphorus intake ratio was reduced to approximately 1 : 1.

CONCLUSIONS

Based on the above described feeding tests and the evidence presented in an epizoölogical study of osteomalacia during the present investigation, it is believed that the following conclusions may be drawn:

No evidence was obtained which indicated that equine osteomalacia is due to disturbances of internal secretions, parasitic infestations, heredity, or infections. Evidence of vitamin deficiencies was not noted.

The production of equine osteomalacia was due to a ration containing a large amount of phosphorus in proportion to the calcium intake of the animal. It has been shown that the amount of calcium intake is of secondary importance to the calcium-phosphorus ratio. Osteomalacia will develop in animals when the ratio of calcium oxide to phosphorus pentoxide is 1 : 2.9. The condition did not develop during a nine-month period when this ratio was 1 : 1.9. Evidence is presented showing that the calcium content of the drinking water was of particular importance.

Feeding experiments with affected animals showed that the condition was arrested and anabolic processes stimulated when the ratio of the calcium oxide-phosphorus pentoxide intake was 1 : 0.9, 1 : 1.0, and 1 : 1.4. The condition progressed in affected animals when this ratio was 1 : 2.3, 1 : 2.4, 1 : 2.5, and 1 : 3.

PATHOLOGY

Macropathology.—In 1905, Friedberger and Fröhner(5) gave a classical description of the macroscopic picture of the bones of animals suffering from osteomalacia, saying that the condition manifested itself chiefly as a decalcification and softening of the bones from within outward accompanied by hyperemia and with the conversion of the bony tissue into a fibrous, soft mass, there being a fatty degeneration and atrophy of the bone cells together with an enlargement of the medulla and a thinning of the cortex. They noted that the change varies with the severity of the affection and that, on close examination of slight cases, there is an increased blood supply and enlarged blood vessels may be seen in the bones. Their sections showed "small dots of blood," the marrow being permeated by numerous small extravasations. They also called attention to the fact that the inner surface of the cortex showed numerous small bony plates detached from the cortical mass. They found that in severe cases the medulla increased to such an extent that it penetrated into the epiphyses and that the marrow became soft, gelatinous, even watery, and had a "dirty yellow color." Law(7) in 1911 reported that on the articular ends of affected bone, granulation tissue penetrates into and through the articular cartilages and that the changes are greatest in the bones of the face. Many writers note that inflammatory reactions are present frequently in the joints of animals affected with osteomalacia. Goldberg(76) in 1917 pointed out that inflammation of the joints of horses are commoner than is generally supposed, appearing in the joints of apparently healthy animals in numerous instances and that the lesions most frequently found in these cases are fibrous outgrowths on the synovial membrane and erosions on the articular surfaces. The writers have noted these lesions in apparently normal animals of advanced age. From these observations it would appear that too much importance cannot be attached to the finding of these lesions in osteomalacia.

Careful study of osteomalacia as exhibited in horses and mules in the Philippines has convinced the writers that all bones of the skeleton are involved in the process, and that the variation in the degree of severity in certain parts of the skeleton is due, probably, to external influences such as mechanical irritation, etc. An illustration of this is the enlargement of the mandible which is due probably to irritation consequent to mastication. Initial gross changes in nearly all instances were noted in bones which have a thin cortex normally such as the mandible. A certain amount of deformity of this bone was noted in practically all cases, there being a thinning and softening of the cortex together with a honeycomb appearance of the medullary portion. In about 5 per cent of the cases similar deformities were found in the facial bones. In many of the cases observed there was a more or less severe involvement of the vertebræ, there being an extreme thinning of the cortex and intervertebral discs. The long bones showed an increase of the medulla at the expense of the cortex. Many detached or partially detached portions of the cortex were noted at the periphery of the medulla. The cortical portion of long bones showed a porosity varying with the severity of the condition. Porosity was found to be much more severe in thick cortices. The outer portion of the cortex showed punctiform hæmorrhages in nearly all instances. These frequently involved the periosteum as well.

In all cases autopsied, severe joint lesions were noted. There were erosions on the articular surfaces of the bones entering into the formation of joints, a thickening of the synovial membrane and, in some cases, the presence of an organized dark yellow exudate.

The marrow of the long bones examined was found to be softer than normal, fatty in appearance, and varied in color from dark yellow to chocolate. The severity varied in different portions of the same bone. Petechial hæmorrhages were common. The autopsy protocol of horse B760 is a typical case.

HOSPITAL RECORD OF HORSE B760

Horse B760.—The following hospital record was obtained: February 21, 1929, admitted to veterinary hospital, Fort Stotsenburg. Diagnosis, tendinitis, acute, flexor tendons, right front. Returned to duty February 23, 1929. November 14, 1929, admitted to veterinary hospital. Diagnosis, contused wound, sole of right front foot. The record shows that January 31, 1930, the animal developed an intertubercular bursitis of the right shoulder. June 27, 1930, the animal was returned to duty. August 14, 1930, admitted to the veterinary hospital with a diagnosis of osteomalacia. September 25, 1930, the animal was transferred to Manila and from November 11, 1930, to January 27, 1931, was used in feeding experiment 1. Clinical examination May 11, 1931, showed a marked enlargement of the mandible and moderate proliferative changes of the facial bones. A slight lordosis was present, and the shoulder joints were prominent. There was a marked shortening of the stride (Plates 1 and 2). The animal was destroyed May 11, 1931.

PROTOCOL

General condition.—The cadaver was thin but not emaciated. Ribs prominent. External examination showed no apparent softening of the bones. Skin, subcutaneous tissue, and musculature were normal apparently.

External examination.—1. Head and neck: A marked bilateral thickening of the mandibular body, together with a rounding of the superior border adjacent to the molar teeth. The nasal bones were enlarged moderately, and the nasal passages were reduced.

2. Trunk: Slight lordosis, prominent shoulder joints, and sunken appearance of the breast.

3. Extremities: Apparently normal.

Internal examination.—1. Head and neck: Thyroids and parathyroids appeared normal. The cortical portion of the rami of the mandible showed thinning in certain areas due, apparently, to an invasion by cancellous and osteoid tissue; islands of soft bone were seen in the remaining cortex. A characteristic ridge formation appeared on the outer surface of both rami of the mandible. There was a thinning of the cortex of the maxillæ. All bones heretofore described were cut easily with the autopsy knife.

2. Thorax: Pericardium and pericardial fluid normal, there being a normal quantity of the latter. Lungs and pleura showed no gross pathology except hypostatic congestion of the lower lobe of the right lung. The heart was normal in size and weight, the musculature and valves being normal. Sections of the vertebral column showed an abnormal relationship between the medulla and cortical bone in that only a shell of the latter remained. The intervertebral discs were thinned. The spinous and transverse processes were softened to such an extent that they were cut readily with a knife (see Plate 13). The spinal cord and fluid appeared normal.

3. Abdomen: Pancreas, adrenals, stomach, kidneys, and liver appeared to be normal. There was no gross pathology evident in the intestines or peritoneum. Serous fluid was normal in quantity and color.

Extremities.—Articular surfaces of the hip joints were involved extensively by an erosive process and erosions of lesser severity were found in all other joints of the extremities (see Plate 12). The erosive processes appeared to be subacute but sufficient to account for the lameness manifested clinically. The joint capsules were thickened markedly. There was an invasion of the joint capsule by a tissue, embryonal in appearance. There was no enlargement of any of the bones of the extremities, but the cortical portion was thinned and showed punctiform hæmorrhages in many places. The marrow was dark brown to chocolate in areas where the process was most severe. On fracture, the long bones showed a marked porosity of the cortex.

The histopathology of this case is given in detail in the following section.

Micropathology.—Wells(27) claims that absorption depends upon a removal of both organic and inorganic substances by osteoclasts followed by the formation of uncalcified osteoid tissue. Hutyra and Marek(12) state that the spaces between the bony pillars as well as the Haversian canals are often seen to be distended and bulging. Most of the bony pillars are ossified only in the middle, the sides of their walls next the marrow having patchlike or, more often, lamellar-formed osteoid borders, sometimes so decalcified that lacunar bulgings with polynuclear giant cells (osteoclasts) are present. Law(7) states that there is an active proliferation of cells in the Haversian systems and marrow spaces and an increased vascularity.

For the study of the micropathology of osteomalacia as exhibited in our cases, specimens were collected from the following case and forwarded to the Army Medical Museum, Washington, D. C.(77) for examination.

Horse B760, heretofore mentioned as animal 2 under Feeding Experiment 1, age 12 years. Diagnosis of osteomalacia August 14, 1930. Autopsy May 11, 1931. Clinical manifestations of the disease were typical at the time of autopsy. Protocol of the autopsy on this animal will be found under macropathology (see Plates 1 and 2). A section of the mandible lateral to the molar teeth showed a tumor mass, cutting easily with a knife but containing lime salts. Under low magnification, the section showed a layer of fibrous tissue overlying a fibrous cortex. Under higher magnification, the cortex of the bone was composed of fibrous tissue. Beneath this, and at right angles to it, were partially decalcified lamellæ. Between them was dense fibrous tissue. Beneath this was a zone where most of the lamellæ had been replaced by fibrous tissue, this zone being approximately 2 millimeters in width. Below this, there was somewhat less destruction of the bony lamellæ throughout the rest of the section. There appeared to be much more fibrous tissue than the interlamellar spaces would normally hold, and this suggested that the bony enlargement was due to the fibrous tissue overgrowth. In areas of bone destruction, giant cells were numerous.

Gross and microscopic appearance of the maxillary bone was the same as that of the mandible, but in the former the process seemed slightly less advanced.

The heart muscle was normal apparently.

A section from the head of the femur showed erosions of the articular surface. The section, as cut, was roughly triangular, with the articular cartilage covering the hypotenuse of the triangle. At the base and apex of this triangular portion the bone approached the normal, as seen under low power, with some fatty marrow between the lamellæ of bone. In the midportion of the triangle there was a loss of substance of most of the lamellæ, with a disappearance of some, the changes becoming less toward the base and apex.

Under higher magnification, low power, there was evident a disorganization of the bone, and a replacement with fibrous connective tissue. The earliest change was evidenced by an erosion of the bony trabeculæ, numbers of foreign body giant cells appearing along the eroded bone. At the same time, there appeared to be a loss of calcium salts in some of the lamellæ. The marrow was gradually replaced by new cellular fibrous tissue of the osteoid type beginning along the edges of the lamellæ, and gradually occupying the marrow space. It also appeared that the continued advance of the process replaced the entire lamellar structure with this fibrous tissue. The articular cartilage over the area where the greatest bone destruction had occurred showed fewer nuclei, and stained peculiarly, the surface appearing somewhat eroded. This was a definite degeneration, but here normally the cartilage is of somewhat different consistency, due to the attachment of joint ligaments.

The section from the bone and marrow of the middle third of the large metacarpal showed that, near the marrow cavity, fibrous tissue was replacing partially decalcified bone, and infiltrating marrow spaces nearest the marrow cavity. This was evidently an early change, and consistent with the diagnosis of osteomalacia, though doubtless there were no gross evidences of the widening of the marrow cavity. This probably would have occurred had the animal lived long enough.

Bone marrow from the proximal end of the femur was fatty in character and showed active hæmopoiesis, which may or may not have been in excess of the normal.

Photomicrographs pertinent to the above-mentioned descriptions are reproduced.

Chemical pathology.—General.—Certain dietetic requirements are necessary for the animal body to maintain normal mineral metabolism and deficiencies or even variations in these requirements may produce disturbances of metabolism and result in clinical manifestations of disease. These requirements include, among others, a sufficient supply of vitamin D, calcium, and phosphorus. The present study of equine osteomalacia has confirmed the opinion of other investigators that the relative proportion of the calcium and phosphorus intake is of prime importance in maintaining normal mineral metabolism of the skeleton. Evidence of disturbed mineral metabolism is indicated, to a certain degree, by the amount of mineral substances the animal retains and by the chemical composition of the blood and of the bones.

Many investigators have demonstrated that variation in the proportion of calcium to phosphorus in the ration will result in the retention of different amounts of these elements. Meigs and Turner(78) showed that the phosphorus assimilation of cows may be reduced by an excess of two or more parts of calcium in the ration to one part of phosphorus. The experiments of Forbes(79) showed that the addition of calcium carbonate or of pulverized limestone to the ration of swine caused a marked increase in the retention of calcium, magnesium, and phosphorus. Orr, Holt, Wilkins, and Boone,(64) experimenting with children, demonstrated by metabolism studies that (*a*) excessive amounts of calcium in the diet increased the total calcium absorption and retention but impaired the phosphorus retention and (*b*) excessive amounts of phosphorus in the diet exercised an unfavorable influence on the calcium metabolism and a larger amount of calcium is lost in the fæces. They believe that the retention of one element in the intestines by an excessive amount of the other in the diet is due to the formation of insoluble phosphates. Karelitz and Shohl(67) showed that a change from a high calcium-low phosphorus intake to a ratio of 1 : 1 resulted in an increased calcium retention. Marek(4) states that the degree of retention of calcium depends upon its ratio with other mineral constituents as well as upon its mutual quantitative ratio to proteins, fats, and carbohydrates. Shohl, Bennett, and Weed(68) state that the ratio of calcium to phosphorus in retention is proportional to the ratio of the same elements in the diet.

Blood chemistry.—As osteomalacia is a disease marked by disturbed metabolic activity, it seemed desirable to ascertain if this activity was reflected by changes in the normal content of the blood constituents. A review of available literature failed to show the results of complete blood chemistry on normal horses. Hayden and Tubangui(80) reported the following results in blood chemical determinations on seven normal horses: Nonprotein nitrogen, 34 milligrams; urea, 17.8 milligrams; uric acid, 2.45 milligrams; creatinin, 1.80 milligrams; and sugar, 106 milligrams per 100 cubic centimeters of blood. The most complete work recorded is that of Holt and Reynolds(81) who, in 1924, determined the hæmoglobin, sugar, urea nitrogen, nonprotein nitrogen, uric acid, and creatinin on a group of normal horses. Their results are shown in Table 10.

TABLE 10.—*Blood chemistry in osteomalacia.*

Constituent.	Cases.	Low.	High.	Average.
Hæmoglobin (Dare or Tallquist method) per cent	136	70.0	98	88.2
Sugar do	141	0.078	0.37	0.109
Urea nitrogen mg	141	7.50	25.0	14.81
Nonprotein nitrogen mg	141	16.50	42.58	25.82
Uric acid mg	138	1.76	6.66	2.76
Creatinin mg	141	0.9	3.0	1.4

Hayden and Fish(82) published in the Report of the New York State Veterinary College, Cornell University (1927–28), the following results on normal horses: Sugar, 102.9 milligrams; urea, 18.7 milligrams; uric acid, 2.45 milligrams; nonprotein nitrogen, 33.9 milligrams; creatinin, 1.81 milligrams.

In the present investigation, normal values for blood constituents were determined on sixty-nine horses that arrived in the Philippines from the United States July 10, 1930. To avoid any possible influence that Philippine forage might have on the determinations, this group was fed American oats and American grain hay during the test period. Complete physical examination by two veterinary officers showed that all animals of the group were normal apparently. The following technic was employed in collecting the specimens:

Blood from the jugular vein was collected before the morning feed. In order to facilitate the determinations, groups of ten animals were bled daily. Specimens for the nonprotein nitrogen, urea nitrogen, creatinin, uric acid, sugar, chlorides, and iron were collected in 50 cubic centimeter tubes containing 20 milligrams of dry sodium oxalate. For the calcium, inorganic phosphorus, and magnesium determinations, specimens of blood were collected in large centrifuge tubes, allowed to clot, and the serum separated by centrifugalization. After collection of the specimens they were taken to the laboratory and the determinations made with the least possible delay. The determinations for nonprotein nitrogen, urea nitrogen, creatinin, uric acid, sugar, and chlorides were made on the protein-free blood filtrate prepared according to the method of Folin and Wu.(83)

The methods of Folin and Wu(83) were used in the nonprotein nitrogen and creatinin determinations. The method for sugar was the improved Folin and Wu(84) method. For the determination of urea nitrogen, the Folin and Wu method, as modified by Craig,(85) was used. The method of Benedict(86) was used for the determination of uric acid. Chlorides were determined by the Whitehorn(87) method. The determination of iron was made according to the method of Wong.(88) The hæmoglobin was calculated from the iron determination. The method for serum calcium determination was that of Kramer and Tisdall as modified by Tisdall(89) and further modified by Clark and Collip.(90) The inorganic phosphorus was determined by the Briggs(91) modification of the Bell Doisy method. The magnesium content was determined on the supernatant liquid from the calcium determination after centrifugalization, plus the first wash fluid, according to the method of Briggs.(92)

Table 11 shows the determination on the above-mentioned group of normal horses and gives the average, maximum, and minimum values for each constituent.

Similar determinations were then made on thirty-six horses showing typical symptoms of osteomalacia. The results of these determinations are given in Table 12.

Analysis of Table 12 shows that the hæmoglobin, nonprotein nitrogen, urea nitrogen, creatinin, uric acid, sugar, chlorides, iron, and magnesium of osteomalacia cases are within the normal limits established, approximately. The serum calcium in the osteomalacia cases shows a reduction of approximately 9 per cent. The inorganic phosphorus of the serum shows an increase of 20 per cent.

The ration on which animals developed osteomalacia was exceedingly high in its phosphorus content as compared with its

TABLE 11.—*Blood chemical determinations on normal horses.*

Animal No.	Percentage of hæmoglobin (calculated).	Milligrams per 100 cc blood.							Milligrams per 100 cc serum.		
		Non-protein nitrogen.	Urea nitrogen.	Creatinin.	Uric acid.	Sugar.	Chlorides as NaCl.	Iron.	Calcium.	Inorganic phosphorus.	Magnesium.
1	74	22.2	13.0	2.00	2.50	80	446	42	10.3	2.94	1.70
2	65	21.4	13.5	1.00	2.00	77	462	37	11.6	3.45	2.24
3	65	23.6	12.5	2.00	3.00	80	462	37	12.1	3.33	2.12
4	67	22.2	13.0	1.00	3.00	74	404	38	11.5	2.94	1.74
5	90	21.4	13.2	1.00	3.00	67	380	51	10.5	3.23	1.70
6	62	21.4	12.5	1.00	4.00	83	371	35	12.3	3.57	2.06
7	74	27.2	13.0	1.00	3.00	94	429	42	11.3	2.86	2.01
8	74	21.0	14.2	1.50	3.00	94	429	42	11.1	3.33	1.96
9	63	21.2	13.7	2.00	2.00	80	462	36	12.8	3.70	2.06
10	69	31.6	13.0	2.28	2.84	74	429	39	12.3	3.85	1.96
11	63	26.1	13.7	2.28	2.10	91	446	36	13.2	3.33	1.78
12	62	23.1	15.8	1.56	2.00	80	446	35	12.9	4.17	2.24
13	65	31.6	12.5	1.65	2.84	83	462	37	13.5	3.23	2.12
14	94	33.3	13.7	2.00	3.63	67	413	53	13.7	3.85	1.91
15	65	30.0	12.5	2.28	2.67	100	479	37	14.0	3.13	1.91
16	69	31.6	18.8	1.56	2.84	91	462	39	14.3	4.00	1.57
17	94	24.0	13.6	2.00	2.66	100	429	53	10.5	3.70	2.45
18	90	27.3	13.0	1.76	2.58	87	446	51	10.9	4.17	2.24
19	99	25.0	13.6	1.81	3.07	100	462	56	11.1	3.70	2.00
20	99	27.3	16.7	1.87	2.22	83	446	56	11.3	3.03	1.85
21	86	28.6	12.5	1.87	2.85	80	462	49	10.2	3.85	2.18
22	79	33.3	11.1	2.14	2.66	87	479	45	11.1	4.00	2.30
23	99	27.3	10.3	2.00	2.00	100	462	56	11.3	3.33	2.18
24	90	28.6	11.1	2.00	2.85	80	429	51	10.7	4.00	1.91
25	83	31.6	12.0	2.00	2.00	83	462	47	11.1	4.17	1.70
26	79	30.8	11.5	1.79	2.05	83	462	45	10.9	4.00	1.57
27	79	33.3	12.0	1.57	2.66	100	479	45	11.8	3.70	1.78
28	76	34.0	13.0	1.57	2.75	95	446	43	11.7	4.35	1.63
29	85	27.3	11.5	1.79	2.96	83	446	48	12.1	4.00	1.57
30	95	32.0	12.0	1.79	2.27	81	413	54	11.5	4.17	1.88
31	74	26.0	13.0	2.00	2.50	91	479	42	10.2	2.63	1.63
32	85	29.3	15.0	1.87	2.42	105	462	48	10.6	3.70	1.63
33	71	27.3	16.7	1.57	3.81	100	413	40	11.7	3.33	1.40
34	88	33.3	21.4	1.76	2.05	95	363	50	12.6	3.85	1.57
35	76	28.6	14.3	1.76	2.00	95	462	43	11.2	5.00	1.60
36	78	33.3	18.3	1.66	2.11	100	495	44	11.0	3.33	1.48
37	104	28.6	13.0	1.50	2.22	91	446	59	11.6	3.57	1.57
38	99	28.6	13.0	1.57	2.22	91	446	56	10.7	3.33	1.88
39	85	30.0	14.3	1.57	2.16	118	446	48	10.5	3.85	1.63
40	79	31.6	13.6	1.87	2.50	118	462	45	11.8	3.85	1.78
41	78	32.5	13.3	1.90	3.20	95	462	44	11.9	3.13	1.74
42	69	30.8	14.3	1.80	4.00	87	495	39	10.6	3.57	1.70
43	85	30.0	12.8	1.76	3.33	83	479	48	10.8	3.85	1.70
44	67	36.0	14.3	1.76	2.33	111	495	38	10.5	3.13	1.48
45	67	35.3	12.5	1.76	3.08	118	462	38	11.2	3.13	1.42
46	74	24.0	12.5	1.66	3.20	100	479	42	10.8	3.13	1.51
47	67	28.6	17.6	1.76	3.08	91	446	38	12.9	3.13	1.67
48	56	30.0	16.7	1.66	2.33	100	479	32	10.2	3.13	1.57
49	86	28.6	15.4	2.72	3.08	87	429	49	10.2	3.85	1.51

TABLE 11.—*Blood chemical determinations on normal horses*—Continued.

Animal No.	Percentage of hæmoglobin (calculated).	Milligrams per 100 cc blood.							Milligrams per 100 cc serum.		
		Nonprotein nitrogen.	Urea nitrogen.	Creatinin.	Uric acid.	Sugar.	Chlorides as NaCl.	Iron.	Calcium.	Inorganic phosphorus.	Magnesium.
50	79	32.5	15.0	1.76	3.08	83	462	45	10.2	4.56	1.35
51	85	27.3	17.2	1.57	2.10	71	446	48	10.9	4.00	1.40
52	76	29.0	17.0	1.42	2.00	80	462	43	10.6	3.85	1.33
53	99	26.8	16.8	1.66	2.00	83	495	56	10.2	3.45	1.40
54	99	33.3	15.4	1.57	3.30	95	446	56	11.0	3.85	1.40
55	76	37.5	18.0	1.76	2.10	91	446	43	10.6	3.45	1.35
56	86	28.6	17.0	1.76	3.48	83	429	49	10.8	4.17	1.51
57	76	28.6	14.3	2.30	4.00	133	495	43	10.8	3.13	1.51
58	74	26.0	13.6	2.30	3.81	125	462	42	10.9	3.85	1.40
59	88	30.0	16.7	2.14	3.20	133	446	50	11.0	3.13	1.40
60	85	33.3	15.0	2.14	3.08	100	429	48	11.2	3.03	1.40
61	74	28.6	13.6	2.00	3.33	125	495	42	11.0	3.03	1.40
62	78	31.6	15.8	2.00	4.00	95	446	44	11.2	3.13	1.33
63	78	27.3	13.6	2.00	3.81	125	479	44	11.1	3.13	1.40
64	76	26.0	14.3	2.14	4.00	111	479	43	11.1	3.13	1.33
65	99	27.5	12.5	1.66	2.50	61	396	56	13.0	3.85	2.18
66	79	26.0	13.3	2.00	2.90	111	462	45	11.5	3.13	1.51
67	99	30.0	17.6	1.80	2.66	71	429	56	11.4	3.13	1.96
68	88	28.6	14.3	2.00	2.66	61	462	50	12.7	3.33	2.06
69	78	27.3	15.8	2.30	3.00	80	479	44	10.9	3.33	1.40
Average	80	28.7	14.2	1.80	2.81	92	451	45	11.2	3.55	1.72
Maximum	104	36.0	21.4	2.72	4.00	133	495	59	14.3	5.00	2.45
Minimum	56	21.0	11.1	1.00	2.00	61	363	32	10.2	2.63	1.33

calcium content. That a high phosphorus intake will result in a reduced serum calcium value and an increased amount of serum phosphorus has been demonstrated by numerous investigators. Binger(93) in 1917-18 reported that intravenous injection of orthophosphoric acid and its sodium salts in dogs caused a diminution in the serum calcium and an increase in the serum phosphorus. Greenwald(94) did not agree with Binger and stated that the reduced calcium is not due to the phosphate ion but to changes in volume of blood, osmotic pressure, etc. This writer obtained similar calcium reduction by injecting sodium sulphate. Many investigators have since confirmed the work of Binger. In 1919, Meigs, Blatherwick, and Cary(95) reported experiments with cattle in which the addition of disodium phosphate to the ration increased the phosphorus concentration of the plasma and reduced the calcium content. Clark(96) demonstrated that animals on a low calcium intake may exhibit a decrease of 20 to 26 per cent in the calcium con-

TABLE 12.—*Blood chemical determinations on horses affected with osteomalacia.*

Animal No.	Percentage of hæmoglobin (calculated).	Milligrams per 100 cc blood.							Milligrams per 100 cc serum.		
		Non-protein nitrogen.	Urea nitrogen.	Creatinin.	Uric acid.	Sugar.	Chlorides as NaCl.	Iron.	Calcium.	Inorganic phosphorus.	Magnesium.
94	72	25.0	13.0	2.00	2.28	77	462	41	9.3	3.45	2.78
101	93	30.3	9.8	2.25	2.00	102	487	53	9.8	3.44	1.41
102	106	26.5	14.6	2.30	2.80	80	446	60	8.6	4.67	1.21
103	104	30.8	13.0	2.06	2.33	80	363	59	8.6	4.67	1.51
104	90	27.8	17.9	2.18	2.25	94	470	51	9.8	3.64	1.31
105	88	20.1	17.2	1.99	2.58	80	479	50	9.9	3.43	1.20
106	88	29.9	16.7	2.40	2.23	83	557	50	10.1	3.94	1.25
107	102	26.8	16.9	1.95	2.68	67	446	58	9.1	4.42	1.14
108	88	22.9	16.7	2.14	2.75	100	495	50	9.9	3.20	1.21
109	84	20.1	13.7	1.95	3.17	73	462	48	9.6	3.97	1.29
111	83	19.5	14.4	1.88	2.28	79	479	47	9.2	4.35	1.21
112	69	22.2	14.5	2.14	2.66	80	413	39	9.5	4.35	1.26
113	67	23.1	15.0	1.75	2.00	83	462	38	10.5	4.35	1.26
114	95	25.0	14.3	2.00	3.20	80	413	54	11.3	4.56	1.20
116	63	20.0	13.6	2.30	2.71	91	462	36	9.2	4.35	2.18
117	56	23.1	16.0	2.30	2.00	77	462	32	8.1	5.87	1.31
118	58	24.0	14.3	2.00	2.10	87	495	33	9.9	3.85	1.57
119	58	25.0	14.3	1.75	2.00	91	495	33	9.9	4.56	1.78
120	67	20.0	15.0	1.75	2.35	100	462	38	11.0	5.00	1.45
121	67	28.6	13.0	3.00	2.50	67	446	38	11.2	5.00	1.96
122	65	35.3	15.0	2.14	2.58	100	495	37	10.8	5.26	1.88
123	76	33.3	13.0	2.00	1.86	91	429	43	10.6	4.76	1.70
124	69	30.0	13.0	2.30	2.28	100	446	39	12.7	3.85	1.67
125	74	27.3	12.5	2.00	2.28	91	446	42	11.8	3.33	1.90
126	70	25.8	10.3	2.00	2.22	100	446	40	10.1	5.00	1.50
127	67	25.0	12.0	2.50	2.58	80	462	38	10.5	4.35	1.27
134	99	28.6	17.5	2.00	3.00	133	495	56	10.1	5.64	1.67
135	76	26.8	15.0	2.00	2.66	87	462	43	10.3	4.56	1.70
136	99	28.6	15.0	2.50	1.86	91	446	56	10.3	4.00	1.67
137	99	22.0	14.3	2.14	3.64	105	462	56	10.9	4.56	1.67
138	88	25.0	15.0	2.14	3.00	86	462	50	11.0	3.85	1.90
139	76	25.0	12.5	1.87	3.08	90	462	43	11.1	4.76	1.45
140	101	27.3	13.6	2.14	3.28	87	446	57	10.6	3.85	1.96
141	95	26.0	14.3	1.87	3.33	83	446	54	10.2	3.70	1.57
142	93	27.3	15.0	2.00	3.84	95	462	53	11.3	3.57	1.29
143	95	30.0	13.0	1.76	2.50	100	462	54	10.8	3.33	1.41
Average	81	25.9	14.3	2.09	2.57	88	460	45	10.2	4.26	1.55
Maximum	106	35.3	17.9	3.00	3.84	133	557	60	12.7	5.87	2.78
Minimum	56	19.5	9.8	1.75	1.86	67	363	32	8.1	3.20	1.20

tent of the blood after phosphate injection. Tisdall(97) demonstrated that a decided reduction of the serum calcium occurred and the serum phosphorus was increased greatly in dogs following intravenous injections of dibasic sodium phosphate. He obtained similar results by intravenous injections of phosphoric acid. Greenwald,(98) however, did not agree with the statements of Tisdall. In 1922, Kramer and Howland(38) showed that if the phosphorus intake of young white rats remained at a normal level and the calcium intake was reduced, the serum calcium was reduced markedly while the serum phosphorus remained normal; an increase in dietary calcium resulted in increased serum calcium. Salvesen, Hastings, and McIntosh(99) demonstrated that large doses of phosphate administered to dogs over a period of one or two days produced violent symptoms similar to tetany, an increase in the serum phosphates, and a reduction of serum calcium. In 1927, Palmer and Eckles(100) reported that cattle fed on hay, which was abnormally low in phosphorus but adequate in calcium content, showed low plasma phosphorus and normal serum calcium. The addition of calcium carbonate did not affect the plasma phosphorus but increased the blood calcium while the addition of sodium phosphate increased the plasma phosphorus and reduced the blood calcium.

Ion products: blood of normal and osteomalacic horses.—In the following table the stoichiometric ion product $(Ca^{++})^3 \times (PO_4^{\equiv})^2$ has been calculated for all cases, both normal and osteomalacic, which have been studied in this series, consisting of sixty-nine of the former and thirty-six of the latter.

pH determinations were made on eighteen normal cases and on twenty cases that were proven to be suffering with advanced osteomalacia. The method used was that described by Cullen,(101) modified by Hawkins,(102) and included, as modified, in the work by Hawk and Bergeim.(103) The average for each of the groups was 7.29. This figure was used in determining the factor (5.28) which was the basis for the calculation of the p product. The work of Holt(104) was used as a guide in the calculations.

$p(PO_4^{\equiv})$ was obtained from p(P) by the addition of the constant 5.28. The negative logarithm of the ion product, p product, was obtained by taking the sum of 3p(Ca) and $2p(PO_4^{\equiv})$. It has been found that in active rickets the p product is greater than 24.10, while in healing cases and normals the p product is less than 24.10.(104) It will be noted by reference to Tables 13 and 14 that our findings are not comparable to those of rickets, the p product being higher in the normals than in the osteomalacia cases. This would seem to be an almost certain indication of the withdrawal of calcium from the bones instead

TABLE 13.—*Stoichiometric ion product* $(Ca{+}{+})^2 \times (PO_4^{\equiv})^2$ *for normal horses.*

Ca.	[Ca ++].	Log. of [Ca ++].	p[Ca ++].	P.	[P].	Log. of [P].	p[P].	$p[PO_4^{\equiv}]$ p[P] +5.28.	p[product].
10.3	2.58×10^{-3}	—3.41	2.59	2.94	0.95×10^{-3}	—2.96	3.04	8.32	24.41
11.6	2.90×10^{-3}	—3.46	2.54	3.45	1.11×10^{-3}	—3.05	2.95	8.23	24.08
12.1	3.03×10^{-3}	—3.48	2.52	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.06
11.5	2.88×10^{-3}	—3.46	2.54	2.94	0.95×10^{-3}	—2.96	3.04	8.32	24.26
10.5	2.62×10^{-3}	—3.42	2.58	3.23	1.04×10^{-3}	—3.02	2.98	8.26	24.26
12.3	3.10×10^{-3}	—3.49	2.51	3.57	1.15×10^{-3}	—3.06	2.94	8.22	23.97
11.3	2.82×10^{-3}	—3.45	2.55	2.86	0.92×10^{-3}	—2.97	3.03	8.31	24.27
11.1	2.78×10^{-3}	—3.44	2.56	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.18
12.8	3.20×10^{-3}	—3.51	2.49	3.70	1.19×10^{-3}	—3.08	2.92	8.20	23.87
12.3	3.10×10^{-3}	—3.49	2.51	3.85	1.24×10^{-3}	—3.09	2.91	8.19	23.91
13.2	3.30×10^{-3}	—3.52	2.48	3.33	1.07×10^{-3}	—3.03	2.97	8.25	23.94
12.9	3.23×10^{-3}	—3.51	2.49	4.17	1.35×10^{-3}	—3.13	2.87	8.15	23.77
13.5	3.38×10^{-3}	—3.53	2.47	3.23	1.04×10^{-3}	—3.02	2.97	8.25	23.91
13.7	3.43×10^{-3}	—3.54	2.46	3.85	1.24×10^{-3}	—3.09	2.91	8.19	23.76
14.0	3.50×10^{-3}	—3.54	2.46	3.13	1.01×10^{-3}	—3.00	3.00	8.28	23.94
14.3	3.58×10^{-3}	—3.55	2.45	4.00	1.29×10^{-3}	—3.11	2.89	8.17	23.69
10.5	2.62×10^{-3}	—3.42	2.58	3.70	1.19×10^{-3}	—3.08	2.92	8.20	24.14
10.9	2.73×10^{-3}	—3.44	2.56	4.17	1.35×10^{-3}	—3.13	2.87	8.15	23.98
11.1	2.78×10^{-3}	—3.44	2.56	3.70	1.19×10^{-3}	—3.08	2.92	8.20	24.08
11.3	2.82×10^{-3}	—3.45	2.55	3.03	0.98×10^{-3}	—2.99	3.01	8.29	24.23
10.2	2.55×10^{-3}	—3.41	2.59	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.15
11.1	2.78×10^{-3}	—3.44	2.56	4.00	1.29×10^{-3}	—3.11	2.89	8.17	24.02
11.3	2.82×10^{-3}	—3.45	2.55	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.15
10.7	2.68×10^{-3}	—3.43	2.57	4.00	1.29×10^{-3}	—3.11	2.89	8.17	24.05
11.1	2.78×10^{-3}	—3.44	2.56	4.17	1.35×10^{-3}	—3.13	2.87	8.15	23.98
10.9	2.73×10^{-3}	—3.44	2.56	4.00	1.29×10^{-3}	—3.11	2.89	8.17	24.02
11.8	2.95×10^{-3}	—3.47	2.53	3.70	1.19×10^{-3}	—3.08	2.92	8.20	23.99
11.7	2.93×10^{-3}	—3.47	2.53	4.35	1.40×10^{-3}	—3.15	2.85	8.13	23.85
12.1	3.03×10^{-3}	—3.48	2.52	4.00	1.29×10^{-3}	—3.11	2.89	8.17	23.90
11.5	2.88×10^{-3}	—3.46	2.54	4.17	1.35×10^{-3}	—3.13	2.87	8.15	23.92
10.2	2.55×10^{-3}	—3.41	2.59	2.63	0.85×10^{-3}	—2.93	3.07	8.35	24.47
10.6	2.65×10^{-3}	—3.42	2.58	3.70	1.19×10^{-3}	—3.08	2.92	8.20	24.14
11.7	2.93×10^{-3}	—3.47	2.53	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.09
12.6	3.15×10^{-3}	—3.50	2.50	3.85	1.24×10^{-3}	—3.09	2.91	8.19	23.88
11.2	2.80×10^{-3}	—3.45	2.55	5.00	1.61×10^{-3}	—3.21	2.79	8.07	23.79
11.0	2.75×10^{-3}	—3.40	2.60	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.30
11.6	2.90×10^{-3}	—3.46	2.54	3.57	1.15×10^{-3}	—3.06	2.94	8.22	24.06
10.7	2.68×10^{-3}	—3.43	2.57	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.21
10.5	2.62×10^{-3}	—3.42	2.58	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.12
11.8	2.95×10^{-3}	—3.47	2.53	3.85	1.24×10^{-3}	—3.09	2.91	8.19	23.97
11.9	2.98×10^{-3}	—3.47	2.53	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.15
10.6	2.65×10^{-3}	—3.42	2.58	3.57	1.15×10^{-3}	—3.06	2.94	8.22	24.18
10.8	2.70×10^{-3}	—3.43	2.57	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.09
10.5	2.62×10^{-3}	—3.42	2.58	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.30
11.2	2.80×10^{-3}	—3.45	2.55	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.21
10.8	2.70×10^{-3}	—3.43	2.57	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.27
12.9	3.23×10^{-3}	—3.51	2.49	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.03
10.2	2.55×10^{-3}	—3.41	2.59	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.33
10.2	2.55×10^{-3}	—3.41	2.59	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.15

TABLE 13.—*Stoichiometric ion product* $(Ca^{++})^3 \times (PO_4^{\equiv})^2$ *for normal horses*—Continued.

Ca.	[Ca ++].	Log. of [Ca ++].	p[Ca ++].	P.	[P].	Log. of [P].	p[P].	$p\left[PO_4^{\equiv}\right]$ p[P] + 5.28.	p[product].
10.2	2.55×10^{-3}	—3.41	2.59	4.56	1.47×10^{-3}	—3.17	2.83	8.11	23.99
10.9	2.73×10^{-3}	—3.44	2.56	4.00	1.29×10^{-3}	—3.11	2.89	8.17	24.02
10.6	2.65×10^{-3}	—3.42	2.58	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.12
10.2	2.55×10^{-3}	—3.41	2.59	3.45	1.11×10^{-3}	—3.05	2.95	8.23	24.23
11.0	2.75×10^{-3}	—3.40	2.60	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.18
10.6	2.65×10^{-3}	—3.42	2.58	3.45	1.11×10^{-3}	—3.05	2.95	8.23	24.20
10.8	2.70×10^{-3}	—3.43	2.57	4.17	1.35×10^{-3}	—3.13	2.87	8.15	24.01
10.8	2.70×10^{-3}	—3.43	2.57	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.27
10.9	2.73×10^{-3}	—3.44	2.56	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.06
11.0	2.75×10^{-3}	—3.40	2.60	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.36
11.2	2.80×10^{-3}	—3.45	2.55	3.03	0.98×10^{-3}	—2.99	3.01	8.29	24.23
11.0	2.75×10^{-3}	—3.40	2.60	3.03	0.98×10^{-3}	—2.99	3.01	8.29	24.38
11.2	2.80×10^{-3}	—3.45	2.55	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.21
11.1	2.78×10^{-3}	—3.44	2.56	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.24
11.1	2.78×10^{-3}	—3.44	2.56	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.24
13.0	3.25×10^{-3}	—3.51	2.49	3.85	1.24×10^{-3}	—3.09	2.91	8.19	23.85
11.5	2.88×10^{-3}	—3.46	2.54	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.18
11.4	2.85×10^{-3}	—3.46	2.54	3.13	1.01×10^{-3}	—3.00	3.00	8.28	24.18
12.7	3.20×10^{-3}	—3.51	2.49	3.33	1.07×10^{-3}	—3.03	2.97	8.25	23.97
10.9	2.73×10^{-3}	—3.44	2.56	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.18
AVERAGE									
11.2	2.85×10^{-3}	—3.45	2.55	3.55	1.15×10^{-3}	—3.05	2.95	8.23	24.87

of a mere failure to deposit or to act as an indicator of quiescence. This is supported by our findings that the phosphorus ratio is high in these animals and that the phosphate intake of animals subsisting on Philippine products is extraordinarily high and requires the addition of calcium to the ration to balance the excessive phosphorus taken in the feed.

Bone.—The study of the chemical changes occurring in the bones of animals affected with osteomalacia has held the attention of many investigators. In 1905, Friedberger and Fröhner(5) reported that the specific gravity of affected bones is diminished, the lime content reduced more than one-half, and the water content increased. Mohler(1) reported (1906) that chemical analysis of bones from affected animals showed a reduction of fat, phosphoric acid, lime, and soda and an increase in organic matter and silicic acid. McCrudden(105) in 1906–07 compared the analysis of the ribs from two horses affected with

TABLE 14.—*Stoichiometric ion product* $(Ca^{++})^3 \times (PO_4^{\equiv})^2$ *for osteomalacic horses.*

Ca.	[Ca ++].	Log. of [Ca ++].	p[Ca ++].	P.	[P].	Log. of [P].	p[P].	p$[PO_4^{\equiv}]$ p[P] +5.28.	p[product].
9.3	2.33×10^{-3}	—3.37	2.63	3.45	1.11×10^{-3}	—3.05	2.95	8.23	24.35
9.8	2.45×10^{-3}	—3.39	2.61	3.44	1.11×10^{-3}	—3.05	2.95	8.23	24.29
8.6	2.15×10^{-3}	—3.33	2.67	4.67	1.51×10^{-3}	—3.18	2.82	8.10	24.21
8.6	2.15×10^{-3}	—3.33	2.67	4.67	1.51×10^{-3}	—3.18	2.82	8.10	24.21
9.8	2.45×10^{-3}	—3.39	2.61	3.64	1.17×10^{-3}	—3.07	2.93	8.21	24.25
9.9	2.48×10^{-3}	—3.39	2.61	3.43	1.11×10^{-3}	—3.05	2.95	8.23	24.29
10.1	2.52×10^{-3}	—3.40	2.60	3.94	1.27×10^{-3}	—3.10	2.90	8.18	24.16
9.1	2.28×10^{-3}	—3.36	2.64	4.42	1.43×10^{-3}	—3.15	2.85	8.13	24.18
9.9	2.48×10^{-3}	—3.39	2.61	3.20	1.03×10^{-3}	—3.01	2.99	8.27	24.37
9.6	2.40×10^{-3}	—3.38	2.62	3.97	1.28×10^{-3}	—3.11	2.89	8.17	24.20
9.2	2.30×10^{-3}	—3.36	2.64	4.35	1.40×10^{-3}	—3.15	2.85	8.13	24.18
9.5	2.38×10^{-3}	—3.38	2.62	4.35	1.40×10^{-3}	—3.15	2.85	8.13	24.12
10.5	2.62×10^{-3}	—3.42	2.58	4.35	1.40×10^{-3}	—3.15	2.85	8.13	24.00
11.3	2.82×10^{-3}	—3.45	2.55	4.56	1.47×10^{-3}	—3.17	2.83	8.11	23.87
9.2	2.30×10^{-3}	—3.36	2.64	4.35	1.40×10^{-3}	—3.15	2.85	8.13	24.18
8.1	2.02×10^{-3}	—3.31	2.69	5.87	1.98×10^{-3}	—3.30	2.70	7.98	24.03
9.9	2.48×10^{-3}	—3.39	2.61	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.21
9.9	2.48×10^{-3}	—3.39	2.61	4.56	1.47×10^{-3}	—3.17	2.83	8.11	24.05
11.0	2.75×10^{-3}	—3.40	2.60	5.00	1.61×10^{-3}	—3.21	2.79	8.07	23.94
11.2	2.80×10^{-3}	—3.45	2.55	5.00	1.61×10^{-3}	—3.21	2.79	8.07	23.79
10.8	2.70×10^{-3}	—3.43	2.57	5.26	1.70×10^{-3}	—3.23	2.77	8.05	23.81
10.6	2.65×10^{-3}	—3.42	2.58	4.76	1.54×10^{-3}	—3.19	2.81	8.09	23.92
12.7	3.20×10^{-3}	—3.51	2.49	3.85	1.24×10^{-3}	—3.09	2.91	8.19	23.85
11.8	2.95×10^{-3}	—3.47	2.53	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.09
10.1	2.53×10^{-3}	—3.40	2.60	5.00	1.61×10^{-3}	—3.21	2.79	8.07	23.94
10.5	2.62×10^{-3}	—3.42	2.58	4.35	1.40×10^{-3}	—3.15	2.85	8.13	24.00
10.1	2.53×10^{-3}	—3.40	2.60	5.64	1.82×10^{-3}	—3.26	2.74	8.02	23.84
10.3	2.58×10^{-3}	—3.41	2.59	4.56	1.47×10^{-3}	—3.17	2.83	8.11	23.99
10.3	2.58×10^{-3}	—3.41	2.59	4.00	1.29×10^{-3}	—3.11	2.89	8.17	24.11
10.9	2.73×10^{-3}	—3.44	2.56	4.56	1.47×10^{-3}	—3.17	2.83	8.11	23.90
11.0	2.75×10^{-3}	—3.40	2.60	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.18
11.1	2.78×10^{-3}	—3.44	2.56	4.76	1.54×10^{-3}	—3.19	2.81	8.09	23.86
10.6	2.65×10^{-3}	—3.42	2.58	3.85	1.24×10^{-3}	—3.09	2.91	8.19	24.12
10.2	2.55×10^{-3}	—3.41	2.59	3.70	1.19×10^{-3}	—3.08	2.92	8.20	24.17
11.3	2.82×10^{-3}	—3.45	2.55	3.57	1.15×10^{-3}	—3.06	2.94	8.22	24.09
10.8	2.70×10^{-3}	—3.43	2.57	3.33	1.07×10^{-3}	—3.03	2.97	8.25	24.21
AVERAGE									
10.2	2.55×10^{-3}	—3.40	2.60	4.26	$1.38\times10_{-3}$	—3.14	2.87	8.15	24.08

osteomalacia with the bones from two normal horses. He reported a decrease in calcium content and an increase in the magnesium, stating that these results confirm the analyses of Roloff (1866) and Chabrie (1895). He also reported that in osteomalacia there is an increase in sulphur and a decrease in phosphorus and inorganic material. In 1907, Ingle(16) reported the analysis of bones from horses, mules, and donkeys affected with osteomalacia and compared these results with analyses of normal bone. He found that normal bone contained larger proportions of ash, lime, and phosphoric acid, and that there was little difference in the composition of bones from affected animals, though much difference in the amount. Ramsey(54) showed that samples of bones of animals reared in sections where osteomalacia was prevalent, contained less lime and phosphoric acid than the bones of animals reared in sections where the disease was not prevalent.

Forbes(3) fed swine a ration in which there was insufficient mineral bases to neutralize the mineral acids present and found that a reduction in the total ash of the bone had occurred, as well as a loss in breaking strength. This writer states that Weiska observed a decrease in the ash of bones from rabbits and sheep that had been fed monosodium phosphate. Bohstadt, Bethke, Edgington, and Robison(106) showed that the average ash content of bones of swine was increased approximately 10 per cent when calcium carbonate was added to a basal ration. These writers showed that a positive correlation existed between the ash content and the breaking strength, and that while the percentage of total ash varied decidedly, the ratio of calcium to phosphorus to magnesium in the ash remained nearly constant.

In the present investigation determinations were made of the ash and chemical composition of bones from affected and normal animals. The tensile strength was determined also. In each instance the left metacarpal bone was used for the determinations. Clinical examination of the animal and X-ray examination of the metacarpal bone were made on each case used in these tests. The total ash determination on eight normal animals ranged from 61.50 per cent to 65.11 per cent with an average of 63 per cent ash. This determination on a total of thirty cases of osteomalacia showed a range of 56.41 per cent to 61.46 per cent with an average of 60.76 per cent ash. Based on the X-ray examination, the bones were grouped according to the degree of rarefaction present. It was found that bones showing the greatest rarefaction, showed the greatest reduction in the percentage of ash. Table 15 shows in detail the ash determinations, while fig. 12 presents these data graphically.

TABLE 15.—*Ash content of normal and osteomalacic bones.*

	Normal.	Osteomalacia.		
		Mild.[a]	Moderate.[a]	Severe.[a]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
	61.66	61.75	59.23	60.37
	65.11	63.25	62.22	59.94
	62.29	59.32	60.67	58.67
	62.02	60.14	59.96	56.66
	61.50	63.88	60.54	61.62
	63.07	60.70	62.92	----------
	64.28	61.67	62.63	----------
	64.04	58.91	61.58	----------
	--------	63.12	59.50	----------
	--------	61.18	60.27	----------
	--------	62.59	60.72	----------
	--------	60.21	56.41	----------
	--------	62.26	----------	----------
Average	63.00	61.46	60.55	59.45
Maximum	65.11	63.88	62.92	61.62
Minimum	61.50	58.91	56.41	56.66

[a] As indicated by X-ray examination.

Average analysis of the ash from bones of eight normal horses showed, calcium, 37.35 per cent; phosphorus, 18.32 per cent; and magnesium, 0.13 per cent. The results on thirty osteomalacic cases were, calcium, 37.54 per cent; phosphorus, 18.23 per cent; and magnesium, 0.19 per cent.

The results of the above analyses confirm the statement that in osteomalacia there is a reduction of the total mineral content of the bone. The percentage of calcium and phosphorus in the bone ash is approximately the same for affected as for normal bone; the magnesium content of ash from osteomalacic bone shows a marked increase.

Comparative tests were conducted to determine the tensile strength of normal and osteomalacic bones. The left metacarpal bone was used in all instances, and the clinical diagnosis of osteomalacia was confirmed by X-ray examination of the bone. In order to correlate variable conditions present in the different specimens—such as, difference in the width and length of the shaft of the bone, thickness of cortex, and extent of medulla, an arbitrary formula was devised and applied in all cases. In devising this formula, the bone at the fracture point (middle of shaft) was considered as being elliptical and the medulla at this point, as circular in shape. Measurements were then taken at the fracture point, the total cross-sectional area calculated and from this was deducted the area occupied by the medullary canal; that is, the cross-sectional area of the cortex at the point of fracture was estimated. The average area for fourteen normal and twenty-six osteomalacic bones was 8.44 square centimeters. The total length of the shaft constituted the span between two stationary supports. Mechanical weight was applied midway between the supports, using a Tinus Olsen (Philadelphia, Pennsylvania) machine devised for testing the tensile strength of materials. It was found that the average span for all bones tested was 15.3 centimeters. The arbitrary formula used to correlate the variable factors is as follows:

$$\frac{\frac{a \times b}{B}\,Y}{y} = A$$

a = kilograms weight to produce fracture.
b = average span of 40 metacarpal bones (15.3 centimeters).
B = span of specimen.
Y = cross-sectional area of cortex at point of fracture of specimen.
y = average cross-sectional area of 40 metacarpal bones (8.44 square centimeters).
A = corrected weight required to fracture specimen.

Using this formula to correct the normal variations found in the metacarpal bones of various individuals, it was found that on 14 normal cases the average weight required was 1,669 kilos, the maximum being 3,615 and the minimum 746. The average age of these horses was 13.9 years. Applying the same calculations and technic to 26 metacarpal bones from osteomalacic horses it was found that the average weight required was 1,145 kilos, with a maximum of 1,817 and a minimum of 620. The average age of the osteomalacia cases was 13.5 years.

In this experiment on the tensile strength of bones it was demonstrated that the metacarpals from horses affected with osteomalacia required an average of approximately 31 per cent less weight to cause fracture than did normal bones under the same conditions.

CLINICAL ASPECTS

General.—During the present investigation it was noted that the individual resistance to osteomalacia was extremely variable, some animals developing the condition within six months after arrival in the Philippines while others, maintained under similar conditions for a period of more than five years, did not develop the disease. As shown elsewhere in this article, mules exhibit a far greater resistance to the condition than do horses. While native animals in some sections of the Philippines show a remarkable resistance to osteomalacia, as was demonstrated by an examination made in Cebu, Cebu, of 275 native ponies of which only two showed clinical evidence of the disease, in other sections the disease is prevalent and constitutes an important economic factor in the development of the live-stock industry.

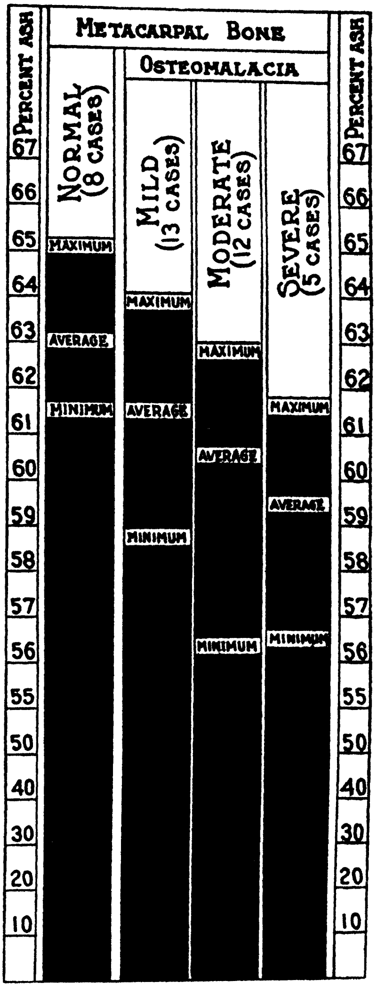


FIG. 12. Ash content of normal and osteomalacic bones.

The rapidity with which the disease developed in Army animals in the Philippines is extremely variable. The shortest period of service before the condition appeared was approximately five months. This case occurred in an 8-year-old horse which arrived in Manila October 18, 1930, was shipped to Fort Stotsenburg December 19, 1930, and was diagnosed as osteomalacia March 7, 1931. The animal was normal on arrival. As compared with this short developmental period, 78 cases occurred during 1930 and 1931, in animals that were brought to Fort Stotsenburg in 1924 or earlier; the date of arrival of this group in the Philippines is not recorded. Out of a shipment of 72 horses and 97 mules arriving in the Islands October 18, 1930, and shipped to Fort Stotsenburg December 19, 1930, two horses, or 2.8 per cent, developed the disease within six months after arrival in the Philippines; of the 97 mules in this shipment, no cases were recorded up to January 1, 1932. The incidence rate of the disease in animals having approximately one year of service at Fort Stotsenburg is shown in Table 16.

TABLE 16.—*Incidence of osteomalacia among animals having approximately one year of service at Fort Stotsenburg.*

Arrived.		Animals in shipment.			Osteomalacia.					
					Horses.		Mules.		Total.	
Philippine Islands.	Fort Stotsenburg.	Horses.	Mules.	Total.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.
Dec. 14, 1929	Feb. 13, 1930	97	145	242	10	10.3	5	3.4	15	6.2
July 10, 1930	Aug. 9, 1930	31	90	121	3	9.7	1	1.1	4	3.4
Total		128	235	363	13	10.1	6	2.5	19	5.2

All cases of osteomalacia noted in the above table, occurred between November 12, 1930, and June 29, 1931. It will be noted that 13 cases, or approximately 10 per cent, of the 128 horses developed the condition in about one year while six, or approximately 2.5 per cent, of the 235 mules developed the disease in the same period.

Table 17 shows the percentage of horses and mules that developed the condition at Fort Stotsenburg during the periods indicated. All animals were shipped to the Philippines in recent years.

TABLE 17.—*Duration of service at Fort Stotsenburg before osteomalacia developed.*

Length of service (approximate) in Philippine Islands.	Animals in shipment.		Osteomalacia.	
	Horses.	Mules.	Horses.	Mules.
Years.			*Per cent.*	*Per cent.*
0.6	72	97	2.8	0
1	31	90	9.7	1.1
1.5	97	145	10.3	3.4
2		159		5.0
2.25	39	24	35.9	0
2.5		125		4.8
3.5	24	90	38.0	10.0
4	88	4	15.9	25.0

Symptomatology.—The symptoms of osteomalacia in animals vary with the species and depend somewhat on the natural position assumed by the animal. Thus, in monkeys, thoracic and pelvic deformity is relatively commoner than in carnivores and rodents due to the fact that the former tend to sit in one position during the developmental period of the disease whereas the latter tend to lie in one position.(24)

The incipient stage in Herbivora shows no recognizable change and the earliest symptoms are changes in the activity of the animal, there being a marked lessening of voluntary movement. Some writers state that perverted appetite is an early symptom but this has not been noted during the present investigation. The disease develops gradually in horses. An intermittent and shifting lameness with no obvious cause, usually manifested by a characteristic shortening of the stride of either the front or hind legs or both, is an early symptom. This lameness is increased by weight-bearing; it may disappear on rest only to recur in some other joint. While standing, the animal usually shifts its weight, thus resting affected parts. The shoulder and hip joints are involved commonly. As the disease progresses, the lameness becomes more marked, the stride exceedingly shortened and a characteristic "tucked-up" appearance of the flanks is present, particularly when the animal is required to trot.

Some cases exhibit a bilateral enlargement of the facial bones at an early stage, while others do not present this symptom even when the disease is well developed. Approximately 5 per cent of the cases examined during the present investigation exhibited proliferative changes of the facial bones. The nasal passages were narrowed when the facial bones were affected. Bony enlargements of the mandible were found in about 98 per cent of the cases examined and this feature provides a valuable, early diagnostic sign. This proliferative change is noted along that portion of the ramus of the mandible in which the lower molar teeth are embedded and is detected readily by palpation of the superior, lateral border of the mandible adjacent to the molar teeth. In the normal animal, this mandibular border is smooth and almost perpendicular to the molar teeth; any enlargement, thickening, or ridge at this point should be viewed as suspicious of osteomalacia. This proliferative change is bilateral (see Plate 10). Several cases were seen in which this proliferative change of the mandible was the only symptom apparent. Some cases show periarticular exostoses. When the disease is fairly well advanced lordosis may be present. A depression of the ribs sometimes occurs that causes a deformity of the chest, as a consequence of which the shoulder joints appear to be displaced forward causing a sunken appearance of the sternum (see Plates 1 and 3). Fractures and torn ligaments may occur but are not frequent, because of the fact that affected animals are destroyed usually before the condition has advanced to the stage where fractures might occur. Fractures of the cervical and lumbar vertebræ and of the metatarsal bones, and torn ligaments of the hock joint occurred among our experimental animals. Enlargement of the ribs at the costochondral junction was noted in several cases.

In the early stage of the disease the animal appears to be well nourished but later becomes poor in flesh, the hair coat becomes rough, anorexia develops, and the animal experiences difficulty in rising. The temperature remains normal. Several cases observed showed an intermittent leucocytosis, the white cell count reaching 17,000 in some.

The age factor has been discussed elsewhere.

DIAGNOSIS

Clinical.—During the early stage of the disease, marked by an intermittent, shifting lameness only, diagnosis is difficult, particularly when exostoses or other pathological conditions are present concurrently. The lameness is diagnosed frequently as spavin or ring bone lameness, arthritis, bursitis, rheumatism, etc. The disease may be suspected when lameness, shifting and intermittent in character and without apparent cause, is present. In the majority of cases the first bone deformity to appear is the characteristic rounding of the superior border of the mandible lateral to the molar teeth. It is believed that this deformity is pathognomic of osteomalacia in the Equidæ. In later stages of the disease, the stride is characteristic, it being markedly shortened and choppy.

X-ray.—We were unable to find references in available literature referring to X-ray findings in equine osteomalacia. In routine X-ray examinations, the metacarpal bones were selected, primarily because of the ease with which X-ray pictures of this bone could be made and it is believed that these bones show all pathological details that might be found in other bones. The technic follows:

Restraint of subject.—Numerous attempts were made to obtain X-ray pictures of the metacarpal bone with the animal in the standing position. These were unsatisfactory, as the slightest movement destroyed the detail of the picture and it was found necessary to use an equine operating table (H. & D., Kyle) in order to arrest completely all movement of the part.

X-ray equipment.—A portable, bedside unit (Waite Dartledt Co., New York) equipped with Coolidge, radiator-type tube was used. Cassettes fitted with double intensifying screens completed the equipment. A constant distance of 20 inches and a milliamperage of 8 was used. The time of exposure varied from 5 to 8 seconds depending upon the thickness of the metacarpal bone.

X-ray findings.—No enlargement was evident in any of the metacarpal bones examined. The most striking feature was a haziness of outline both in the cortical and medullary portions of the bone. There was an indistinct outline between the cortical and medullary portions throughout the length of the bone and an irregular thinning of the cortical portion with a replacement by the medullary cavity. Longitudinal striations, indicating a decalcification process, were present in the compact portion of the metacarpal bone in all clinical cases. Apparently normal animals of advanced age may show some striations of the cortex (senile osteoporosis). The inner outline of the cortex was irregular, showing that the destructive process of compact bone was operating from within outward. In many cases there was a very definite roughening at the tendinous attachment of the extensor carpi radialis muscle. The sesamoid bones show usually a rarefaction and striation equally as extensive as that found in the metacarpal bones. It is believed that the X-ray affords an accurate means of diagnosing osteomalacia. Plates 23 and 24 illustrate X-ray findings in normal bone, mild, moderate, and severe osteomalacia. Negatives have not been retouched for any X-ray photographs used in this article.

Chemical.—It has been shown that in equine osteomalacia there is a decrease in the serum calcium and an increase in the inorganic phosphorus of the serum. These changes are not constant throughout the course of the disease. A series of daily determinations of serum calcium and phosphorus was made on a number of typical cases of the disease and it was found that on some days these elements were present in the blood in normal amounts. For the above reasons, a single determination of the serum calcium and phosphorus is likely to be inconclusive. It is believed that a series of daily determinations would be of diagnostic value.

Course and prognosis.—Equine osteomalacia is usually chronic in character and, with temporary improvements and relapses, may extend over a period of several years. The majority of cases develop slowly and the animal remains semiserviceable for a comparatively long period of time. Some cases, however, develop within a short time and the animal becomes unserviceable within six to eight months. Hard work and adverse conditions of animal management seem to hasten the course of the disease. Individual resistance of the animal, pregnancy, and gestation have some influence on the course of the disease undoubtedly. Spontaneous recovery may occur although this is unusual.

Fig. 13 shows the disposition of 340 cases of the disease which occurred at Fort Stotsenburg during the period July 1, 1930, to July 1, 1931.

With the application of proper corrective measures to the ration, many cases recovered completely and were restored to full military duty. Several experimental cases were returned to duty after two months treatment, and at the completion of the experiment, nine months later, these animals were still doing duty, having suffered no relapses during this period. While the bony proliferations of the head persisted invariably, several instances were noted in which these enlargements subsided in a small degree.

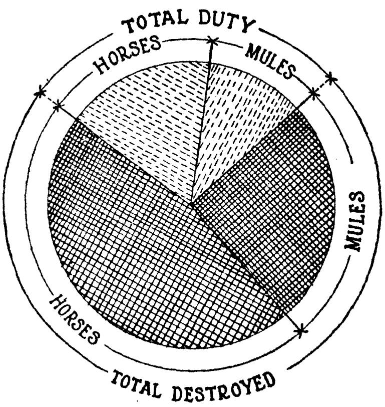


FIG. 13. Disposition of osteomalacia cases at Fort Stotsenburg from July 1, 1930, to July 1, 1931 (340 cases).

Records show that 224 cases were destroyed. The ages of these animals are shown in Table 18. Fig. 14 shows the number of animals in age groups of two years each and the percentage of cases in each group.

PREVENTION AND TREATMENT

At this time we wish to emphasize the fact that all statements made heretofore and to be made hereafter apply only to the osteomalacia in horses with which we have been dealing in the Philippines. We are not prepared to say whether these

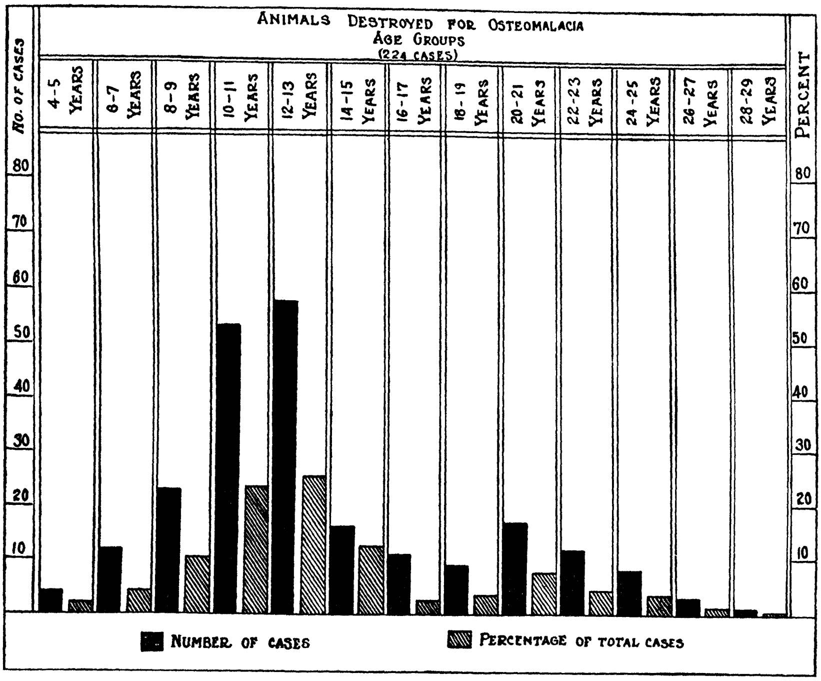


FIG. 14. Age groups of animals destroyed for osteomalacia at Fort Stotsenburg.

TABLE 18.—*Ages of animals with osteomalacia destroyed at Fort Stotsenburg from July 1, 1930, to July 1, 1931 (224 cases).*

Age in years.	Horses.	Mules.	Age in years.	Horses.	Mules.
5	3	2	17	----------	1
6	4	1	19	5	4
7	1	6	20	5	1
8	5	----------	21	8	3
9	16	2	22	2	2
10	17	6	23	5	3
11	28	3	24	6	2
12	28	10	26	1	2
13	16	4	29	----------	1
14	9	1			
15	4	2			
16	3	2	Totals	166	58

statements will apply to osteomalacia as found in the same animals in other locations or in other animals.

The prevention of equine osteomalacia in the Philippines depends entirely on the feeding of a ration properly balanced, with special reference to its mineral components. We have been unable to demonstrate any vitamin deficiency. The ration should be balanced in such a manner that the calcium oxide-phosphorus pentoxide intake ratio is between 1 : 1 and 1 : 1.8. This balance may be obtained by the addition of calcium to the ration direct or through its addition in the natural water supply.

Reference to fig. 15 will show that osteomalacia did not occur at Fort Mills (Corregidor) where the water supply contained a relatively large proportion of calcium and that the case rate

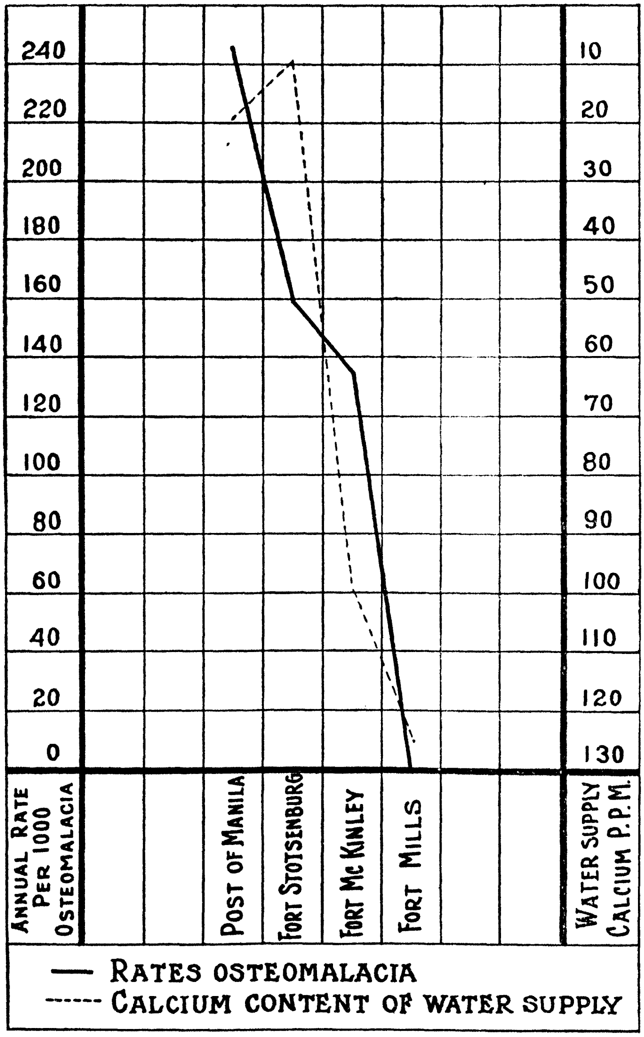


FIG. 15. Comparison of osteomalacia incidence and calcium in water supply.

increased at other posts approximately in proportion to the drop in the calcium content. It must be remembered in this connection that the conditions were otherwise identical at all posts. This includes ration, animal management and care, working conditions, etc.

Fig. 16 shows graphically the total admission rate (less infectious diseases) and admission rate for osteomalacia prior to and subsequent to the institution of a new ration wherein the calcium oxide-phosphorus pentoxide intake ratio was balanced at a figure of approximately 1 : 1.

It has been shown that there was a sharp increase in the admission rate for osteomalacia for the year 1930. It is our belief that this is in part artificial due to the fact that a complete survey of all animals on the post had not been held prior to 1930 and the additional fact that a certain number of osteomalacia cases were diagnosed probably as other conditions prior to this time. It has been shown that since the general admission rate for all conditions, other than infectious diseases, was high prior to 1930, osteomalacia cases probably existed in great numbers prior to that year. It will be noted that, subsequent to the institution of the new ration in June, 1931, there was a prompt and marked drop in the osteomalacia cases reported and at the same time a drop in the general admission rate for all causes other than infectious disease. This but supports our contention that osteomalacia has been included, for the most part, in the guise of other disease entities prior to 1930.

No medicinal treatment was employed in any case except for symptomatic conditions, the results obtained following the alteration in the ration only.

COMMENTS AND CONCLUSIONS

1. A comprehensive review of available literature has been undertaken and pertinent excerpts included herewith. History and occurrence of the disease as a world-wide entity has been commented upon, while in the Philippines the same subjects have been discussed in detail. Similar diseases and those diseases for which osteomalacia has been mistaken have received their share of attention.

2. The great economic importance of osteomalacia to the United States Army in the Philippines and to a lesser extent to the civilian population cannot be overemphasized. In so far as the Army is concerned it has resulted in serious interference with

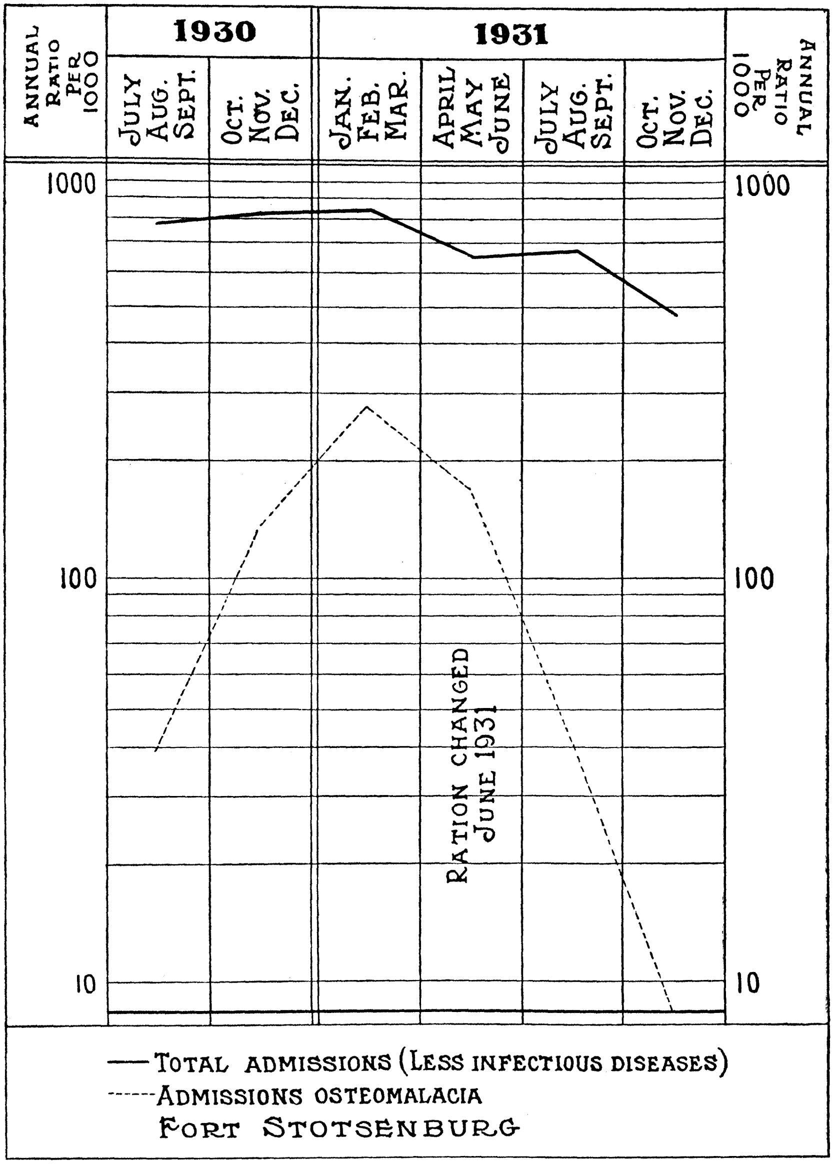


FIG. 16. Total admission rates and rates for osteomalacia at Fort Stotsenburg.

transportation and a monetary loss that cannot be calculated accurately but is high undoubtedly.

3. Native forage cannot be utilized, unsupplemented by mineral additions, but can be taken advantage of provided the calcium-phosphorus ratio is adjusted properly, either by increments of calcium from the natural water supply or by the addition direct to the ration. This latter is required at all

Army posts in the Philippines except Fort Mills (Corregidor). The fact that native forage can be used by the Army in the Philippines results in an advantage to the local population in that they are enabled to dispose of a large quantity of forage for the feeding of Army animals; the United States Government is not dependent entirely on imported forage, is saved the cost of shipment, and the reduced price of certain forage products obtainable in the Philippines is an additional advantage.

4. Diseases affecting the bones and organs of locomotion were found to be more prevalent in Army animals in the Philippines than in like groups in the United States.

5. Osteomalacia affects mules as well as horses, but the former exhibit far more resistance. The disease affects animals of all ages but particularly those animals in the age group between six to thirteen years. No evidence was found indicating that sex played any part in the development of the disease. The effects of pregnancy could not be studied due to the fact that breeding is not an activity of the Army in the Philippines.

6. The cause of the osteomalacia exhibited by Army animals in the Philippines appears to be due solely to a mineral imbalance. There was no evidence that disturbance of internal secretion, parasitic infestation, heredity, infection, or vitamin deficiency played any part in the production of the disease. It has been found that in the prodromal stage as well as in the stage of active manifestation of osteomalacia there is a reduction in serum calcium and an increase in inorganic phosphorus and that this relationship may be altered by the administration of an increased ratio of calcium resulting in an improvement of the condition. It seems fair to conclude that a reduction in the phosphate intake would accomplish the same results since an increase in the phosphorus intake ratio resulted in an increase in the severity of the disease.

7. Macro- and micropathology have been discussed in detail. It has been found that the condition dealt with is definitely osteomalacia, and not the so-called osteoporosis, by reason of the fact that there is a definite replacement of the mineral salts in the bones by osteoid tissue.

8. Average blood-chemical findings on nonprotein nitrogen, urea nitrogen, creatinin, uric acid, and sugar on sixty-nine normal horses have been added to a rather meager literature on the subject. The hæmoglobin as calculated from the iron content, iron, chlorides as sodium chloride, calcium, inorganic phos-

phorus, and magnesium have been determined for the same number of normal animals. The latter determinations form the first comprehensive work on the subject.

The same determinations have been made on thirty-six cases of osteomalacia. The only noteworthy difference between the normal and the osteomalacic case was found in the calcium and inorganic phosphorus.

Stoichiometric-ion-product determinations on all normal and osteomalacic cases are included and indicate withdrawal of calcium from preformed bone and not a simple failure to deposit calcium.

9. The ash content of the bones of osteomalacia cases has been found to be lower than that in normal cases. The average analysis of the ash of eight normal and thirty osteomalacic cases is reported.

10. Comparative tests were conducted to determine the difference in tensile strength between normal and osteomalacic bones, it being determined that in fourteen of the former, an average of 1,669 kilos was required to produce fracture while in twenty-six of the latter, the average weight required was 1,145 kilos. The average age of all animals of both classes was approximately the same.

11. It has been noted that, while mules are much more resistant to osteomalacia than horses, the disease does occur in these animals.

12. It has been found that osteomalacia may develop within a period of approximately five months after arrival in the Philippines but may be long delayed, depending upon individual resistance and mineral constituents consumed apparently.

13. The use of the X-ray as an accurate means of diagnosis is recommended.

14. A serious outbreak of osteomalacia among Army animals in the Philippines has been controlled by the adjustment of the calcium oxide-phosphorus pentoxide intake ratio.

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TABLE 19.—*Analyses of feed.*

	Total dry matter.	Moisture.	Average digestible nutrients.			
			Protein.	Carbohydrates.	Fat.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Oats	[a] 90.8	[a] 9.2	[a] 9.7	[a] 52.1	[a] 3.8	[a] 70.4
Yellow native corn [b]	89.1	10.8	[c] 6.1	[c] 70.6	[c] 4.3	[c] 86.4
Palay [b]	90.6	9.4	[c] 3.9	[c] 64.0	[c] 2.2	[c] 72.9
Copra meal [b]	94.2	5.8	[c] 17.6	[c] 40.4	[c] 8.0	[c] 76.0
Wheat bran	[a] 89.9	[a] 10.1	[a] 12.5	[a] 41.6	[a] 3.0	[a] 60.9
American grain hay	[a] 88.0	[a] 12.0	[a] 4.5	[a] 38.1	[a] 1.7	[a] 46.4
Rice hay [b]	92.5	7.5	[b] 2.5	[c] 41.3	[c] 1.1	[c] 46.3
Zacate (green grass) [b]	38.5	61.5	[c] 2.7	[c] 19.2	[c] 0.8	[c] 23.7

	Average chemical composition.[b]			Ratio.	
	Ash.	CaO.	P_2O_5.	Nutritive.	Mineral.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Oats	3.47	0.06	0.51	1 : 6.3	1 : 8.5
Yellow native corn [b]	1.38	Trace.	0.76	1 : 13	----------
Palay [b]	7.01	0.11	0.59	1 : 17.5	1 : 5.4
Copra meal [b]	6.52	0.08	1.05	1 : 2.8	1 : 13.1
Wheat bran	5.17	0.07	2.40	1 : 3.9	1 : 34.3
American grain hay	5.78	0.19	0.23	1 : 9.3	1 : 1.3
Rice hay [b]	11.56	0.20	0.29	1 : 17.5	1 : 1.4
Zacate (green grass) [b]	5.05	0.12	0.23	1 : 7.7	1 : 1.9

[a] Henry and Morrison, Feeds and Feeding, 18th ed.

[b] Analysis made by Bureau of Science, Manila.

[c] Computed from analysis by Bureau of Science, Manila, and digestion coefficients of similar products published by Henry and Morrison, Feeds and Feeding, 18th ed.

TABLE 20.—*Chemical analyses of water.*

	Manila.	Corregidor.	Nichols Field.	Fort Stotsenburg.	Fort McKinley.
Color	Nil.	Nil.	Nil.	Nil.	Nil.
Odor	Nil.	Nil.	Nil.	Nil.	Nil.
Turbidity (as SiO_2)	5	Trace.	5	Trace.	5
Alkalinity (as Ca CO_3)	60	155	295	63	225
Acidity (as CO_2)	----------	25	19	3	12
Total solids	105	1,035	490	160	1,060
Appearance on ignition	----------	(a)	(a)	(a)	(a)
Silica (SiO_2)	20	120	100	90	----------
Iron and aluminum oxides ($Fe_2O_3+Al_2O_3$)	5.6	2	3.2	2.4	4.4
Iron (Fe)	0.5	0.05	0.28	0.22	0.5
Aluminum (Al)	2.5	1	1.5	1.1	1.9
Calcium (Ca)	19.5	125	33	9.7	99
Magnesium (Mg)	5.3	46	----------	5	27
Arsenic (AS)	----------	Nil.	Nil.	Nil.	Nil.
Chlorides (Cl)	1.5	380	53	2.5	405
Bicarbonates (as H_2CO_3)	70	185	360	76	275
Sulphates (SO_4)	4	----------	10	Trace.	28
Total hardness (as $CaCO_3$)	70	505	145	45	360
Taste	----------	Normal.	Normal.	Normal.	Normal.

[a] Slight darkening.

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ILLUSTRATIONS

PLATE 1. HORSE B760

PLATE 2. X-RAY OF LEFT METACARPAL, HORSE B760

FIG. 1. November 11, 1930.
2. January 27, 1931.

PLATE 3. HORSE C442

PLATE 4. X-RAY OF LEFT METACARPAL, HORSE C442

FIG. 1. November 11, 1930.
2. January 27, 1931.

PLATE 5. HORSE 74B9

PLATE 6. X-RAY OF LEFT METACARPAL, HORSE 74B9

FIG. 1. November 11, 1930.
2. January 27, 1931.

PLATE 7. X-RAY OF LEFT METACARPAL, HORSE 76C3

FIG. 1. January 24, 1931.
2. April 24, 1931.

PLATE 8. X-RAY OF LEFT METACARPAL, HORSE O9V2

FIG. 1. January 24, 1931.
2. April, 1931.

PLATE 9. X-RAY OF LEFT METACARPAL, HORSE B776

FIG. 1. July 22, 1931.
2. October 28, 1931.

PLATE 10. MANDIBLE

PLATE 11. SKULL

PLATE 12. HEAD OF FEMUR

PLATE 13. CROSS SECTION OF VERTEBRÆ

PLATE 14. JAW

Section from the jaw showing advanced fibrous replacement, with proliferation of the fibrous tissue. There is a zone where trabeculæ still maintain their bony character just beneath the cortex. Immediately beneath this most of the trabeculæ are replaced by fibrous tissue. In the rest of the bone section there is considerable variation in the stage of the process, but all marrow spaces are replaced by this vascular new growth of fibroblastic tissue. × 15.

PLATE 15. JAW

This photograph shows an irregular distribution of the most advanced stages of the process, but all the bone lamellæ are modified in greater or less degree, some of them being completely replaced by fibrous tissue. The least-marked change appears to be just beneath the cortex. × 15.

PLATE 16. MAXILLA

Photograph taken near the base of the larger section. There are many osteoclastic giant cells. This photograph shows the terminal stages in the absorption of the bony lamellæ. × 300.

PLATE 17. MAXILLA

The section includes the pericortical fibrous tissue. There is some erosion of the lamellæ, but bone cells are still distinct. The lamellar spaces are completely filled with vascular fibrous tissue. × 300.

PLATE 18. HEAD OF FEMUR

Low-power photograph showing most of the section from the head of the femur. Advanced bony replacement by fibrous tissue in the center of the picture. Spaces contain marrow at the right and left. Necrotic bone is seen apparently in the marrow spaces. This appearance is caused by the section passing through partially necrosed lamellæ parallel to their surface, which were at right angles to the other lamellæ, which apparently form the boundaries of the spaces. These are particularly well shown to the left of the picture. × 15.

PLATE 19. HEAD OF FEMUR

Section shows practically normal marrow at the top and a partially necrosed bone trabecula, center, and at the bottom the section has passed through another trabecula parallel to its surface, this surface being at right angles to the trabecula in the center. There is some marrow in this space also. × 300.

PLATE 20. HEAD OF FEMUR

Photograph taken from section where some marrow still exists. Slightly degenerated bone lamellæ, showing absorption of the lamellar cortex, with a few osteoclasts, and a deposit of fibrous tissue along the bone about the periphery of the marrow space. The marrow appears essentially normal. × 300.

PLATE 21. HEAD OF FEMUR

Photograph from an area of advanced replacement fibrosis, with many osteoclastic giant cells. × 300.

PLATE 22. BONE AND MARROW, LARGE METACARPAL, MIDDLE THIRD

Photograph of the central portion of the section showing loss of lime salts in the bone adjacent to the marrow cavity. This is indicated by the paler staining. The cortical tissue and the marrow have been lost through technical procedure.

PLATE 23. X-RAY FINDINGS

FIG. 1. Normal.
2. Slight rarefaction.

PLATE 24. X-RAY FINDINGS

FIG. 1. Moderate rarefaction.
2. Severe rarefaction.

TEXT FIGURES

FIG. 1. Admission ratios: "Diseases of Bones and of the Organs of Locomotion."
2. Admission rates for conditions indicated in Table 3.
3. Comparison of osteomalacia admission rates with total admission rates.
4. Comparison of admissions for osteomalacia and admissions for all other causes
5. Number of cases and percentage of total in age groups of two years each.
6. Leucocyte count and temperature chart of horse 1C09.
7. Feeding experiment 1.
8. Feeding experiment 2.
9. Feeding experiment 3.
10. Feeding experiment 4.
11. Comparison of American and Philippine rations.
12. Ash content of normal and osteomalacic bones.
13. Disposition of osteomalacia cases at Fort Stotsenburg from July 1, 1930, to July 1, 1931 (340 cases).
14. Age groups of animals destroyed for osteomalacia at Fort Stotsenburg.
15. Comparison of osteomalacia incidence and calcium in water supply.
16. Total admission rates and rates for osteomalacia at Fort Stotsenburg.

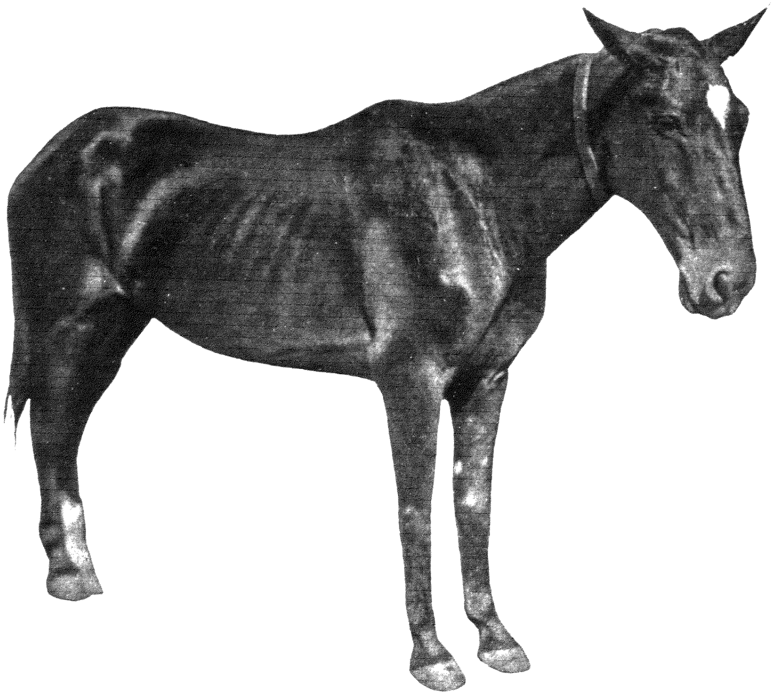

PLATE 1. HORSE B760.

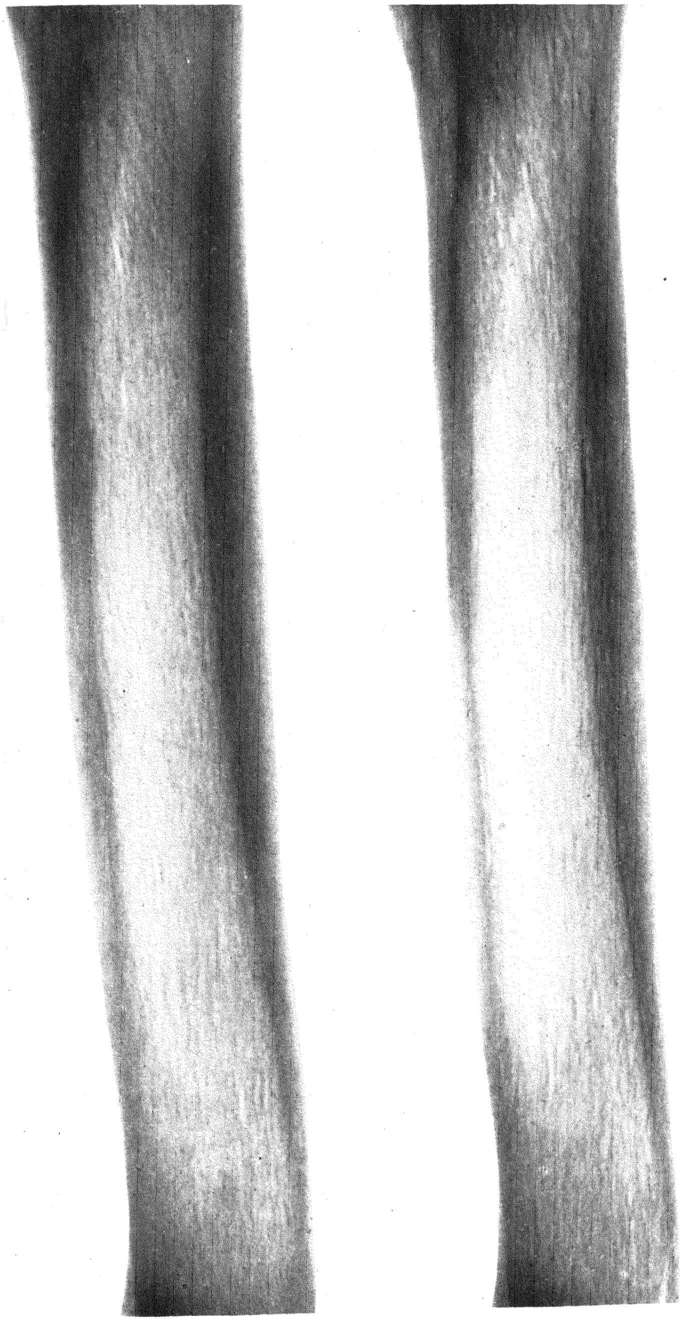

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PLATE 2. X-RAY OF LEFT METACARPAL, HORSE B760. 1, NOVEMBER 11, 1930; 2, JANUARY 27, 1931.

UNIV. OF MICH.

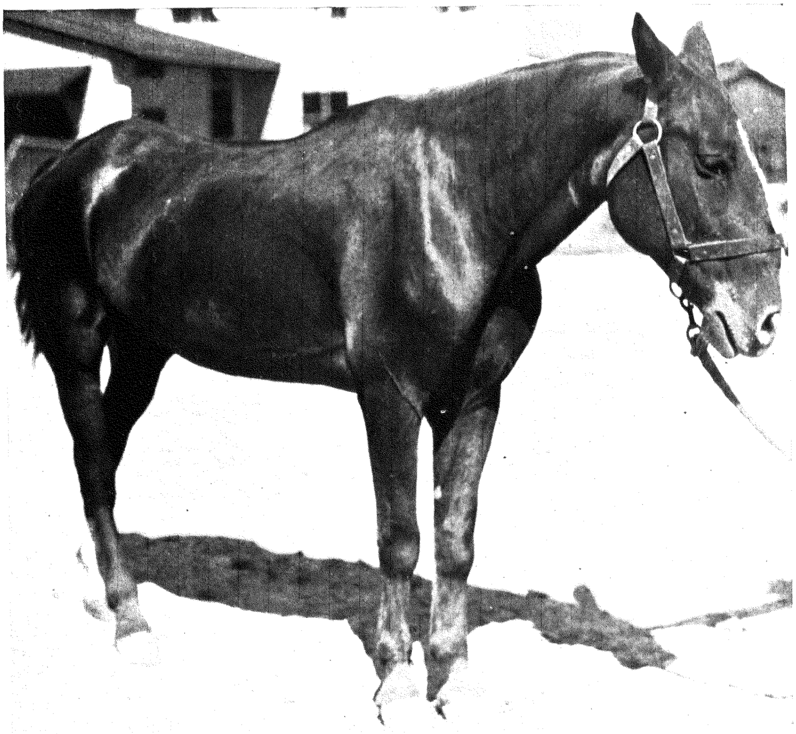

PLATE 3. HORSE C442.

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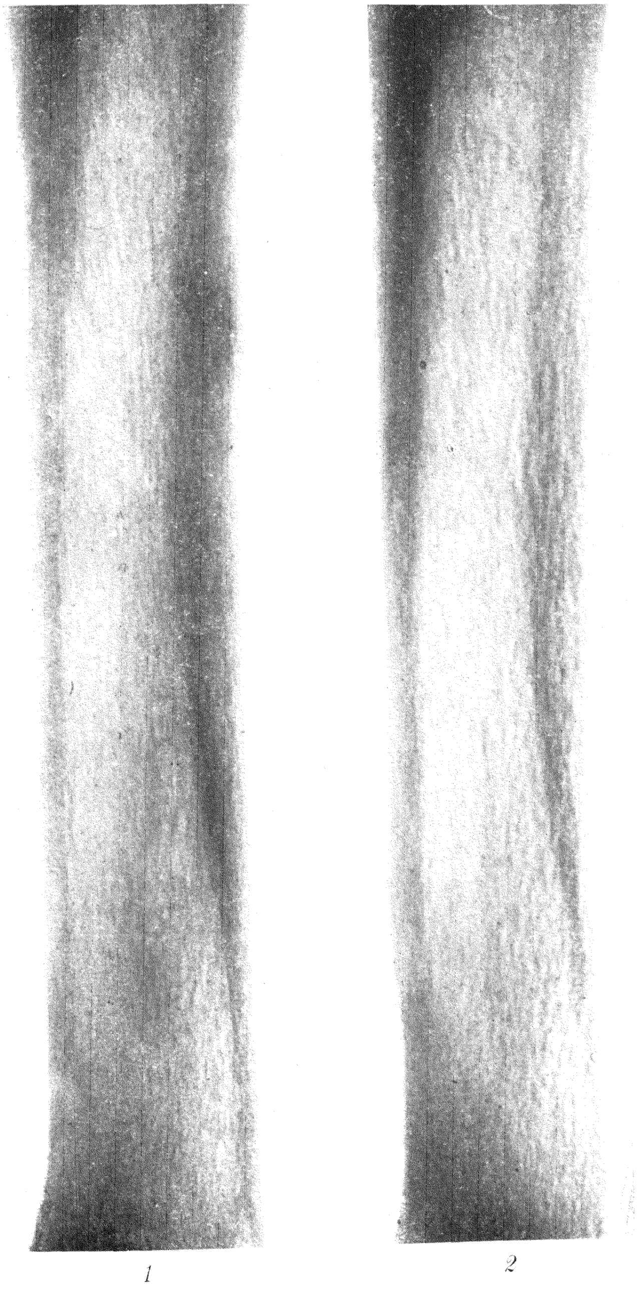

PLATE 4. X-RAY OF LEFT METACARPAL, HORSE C442. 1, NOVEMBER 11, 1930; 2, JANUARY 27, 1931.

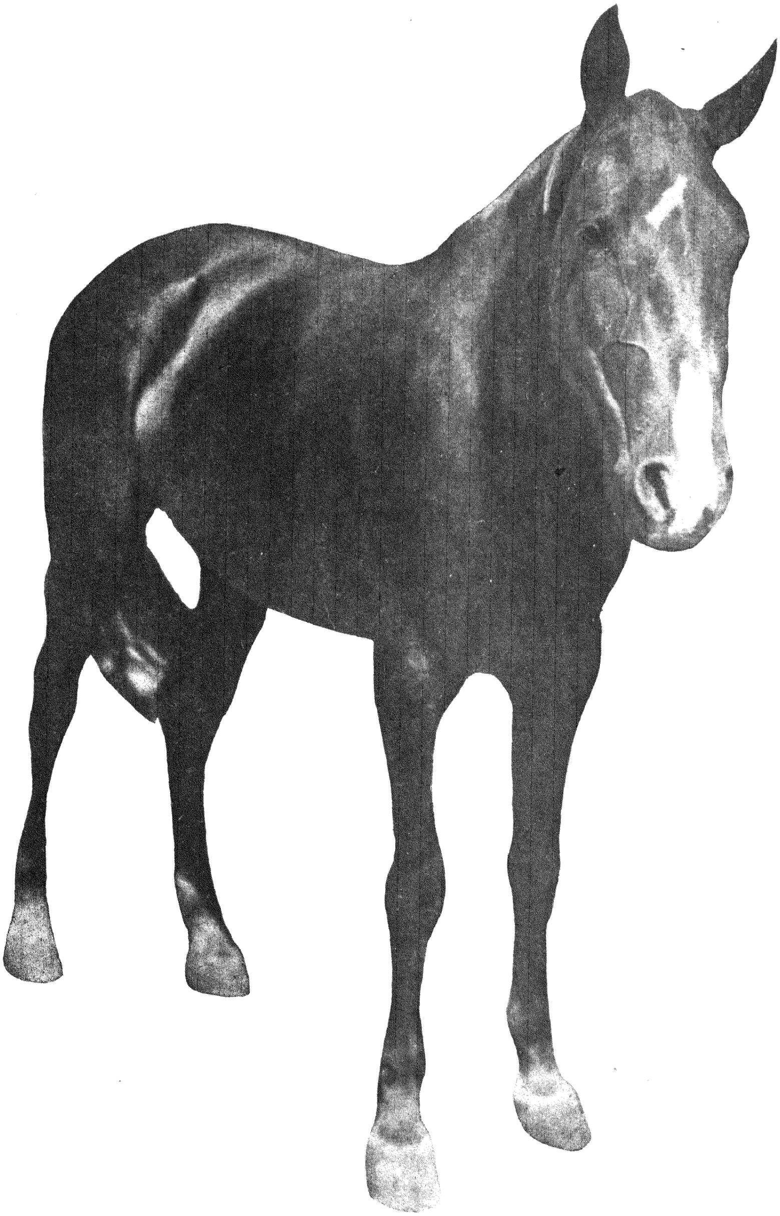

PLATE 5. HORSE 74B9.

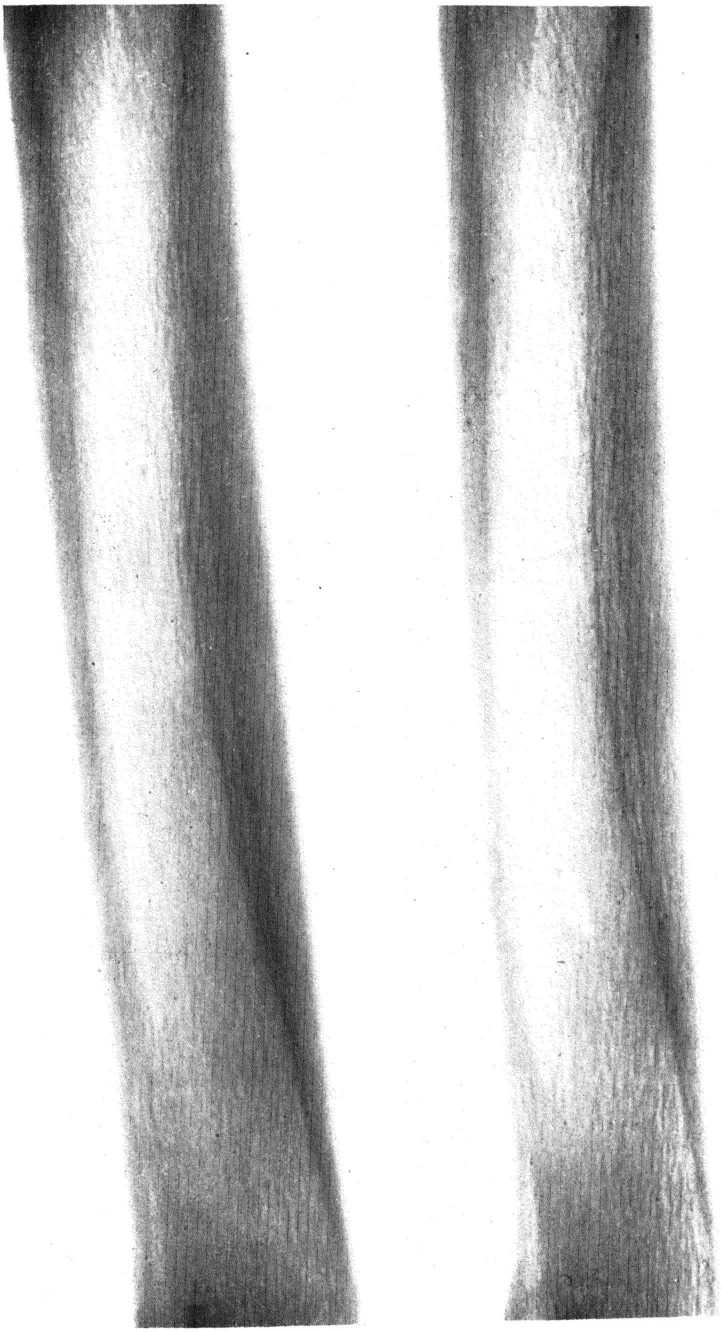

PLATE 6. X-RAY OF LEFT METACARPAL, HORSE 74B9. 1, NOVEMBER 11, 1930; 2, JANUARY 27, 1931.

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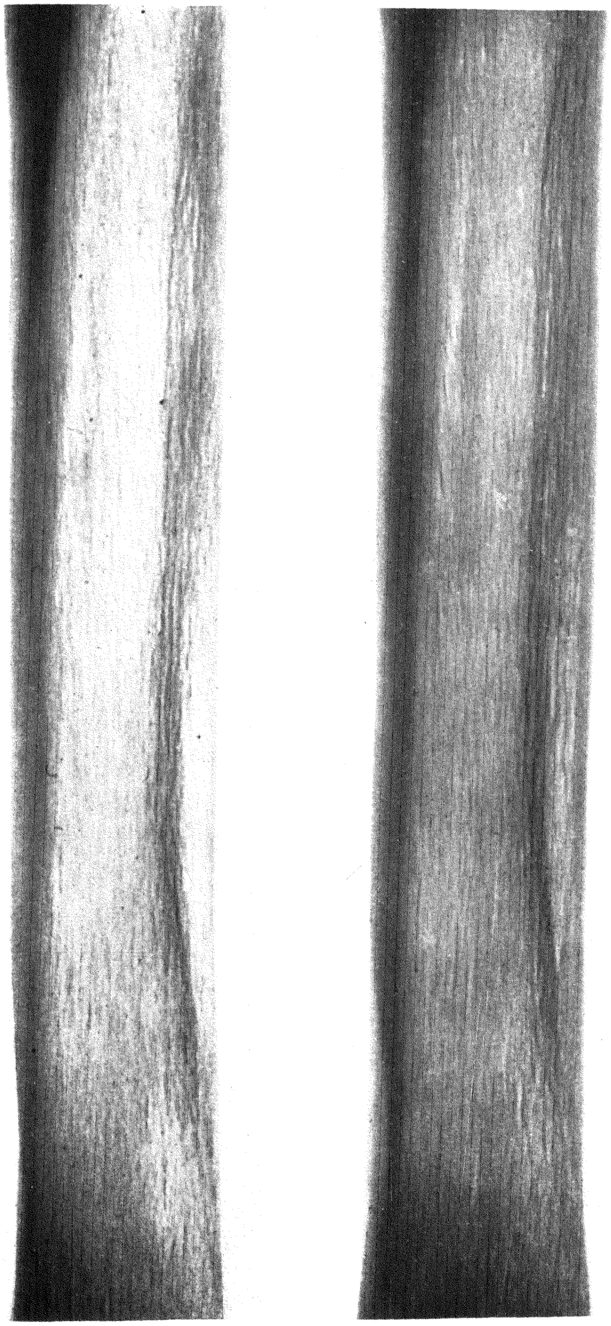

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PLATE 7. X-RAY OF LEFT METACARPAL, HORSE 76C3. 1, JANUARY 24, 1931; 2, APRIL 24, 1931.

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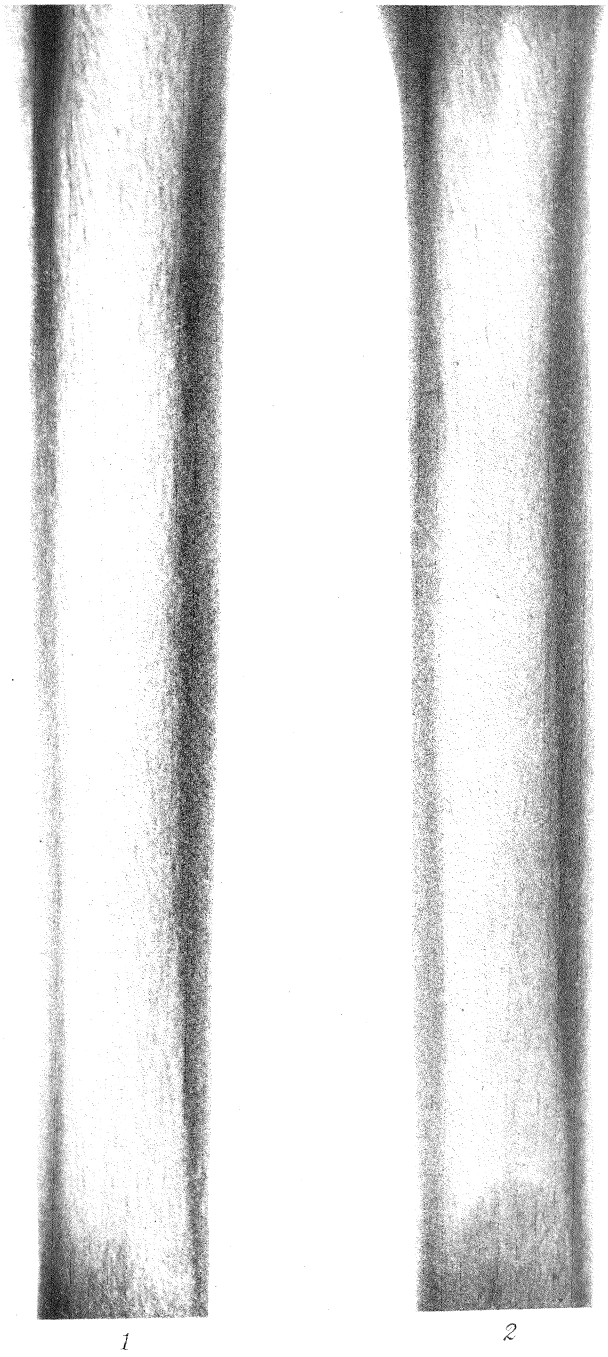

PLATE 8. X-RAY OF LEFT METACARPAL, HORSE O9V2. 1, JANUARY 24, 1931; 2, APRIL 24, 1931.

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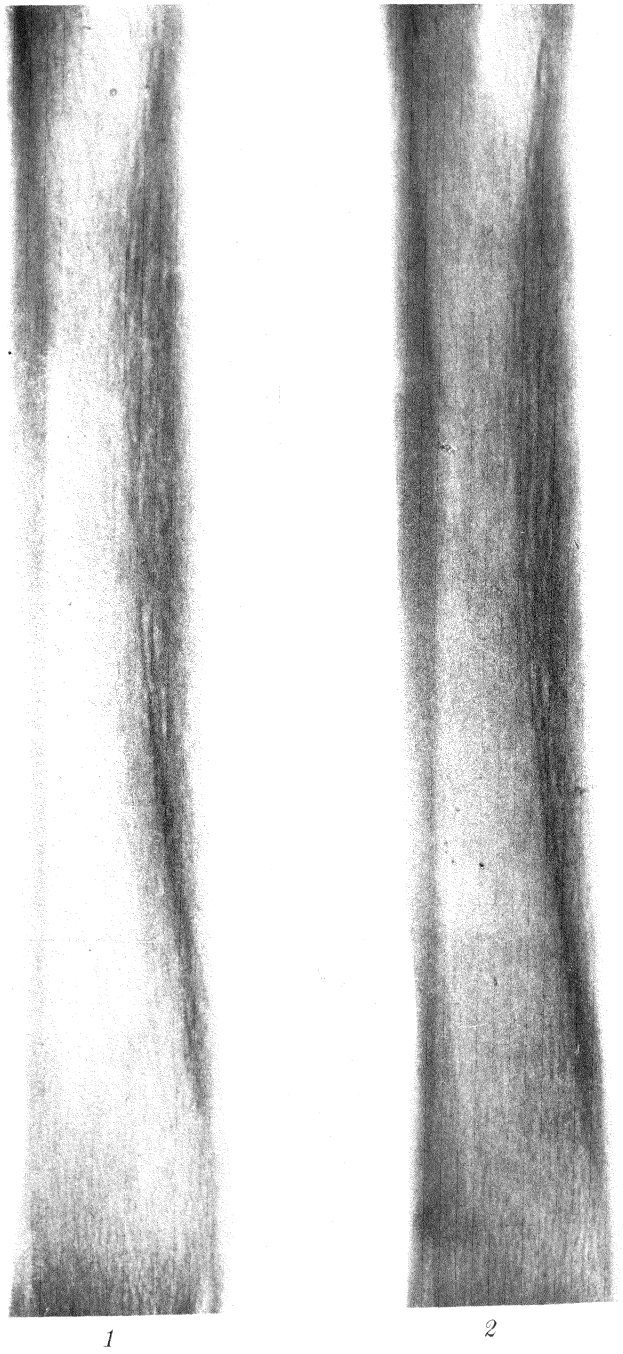

PLATE 9. X-RAY OF LEFT METACARPAL, HORSE B776. 1, JULY 22, 1931; 2, OCTOBER 28, 1931.

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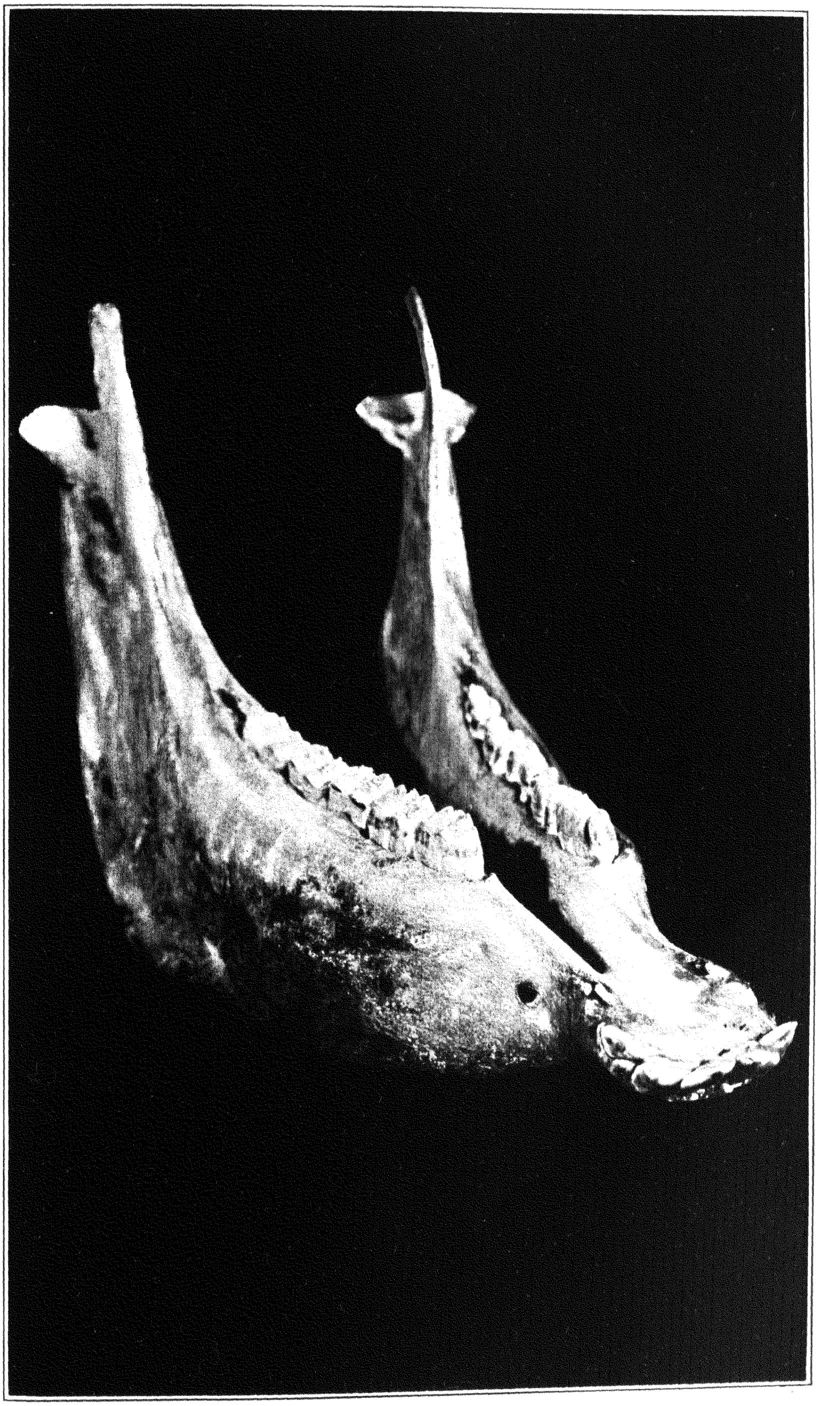

PLATE 10. MANDIBLE.

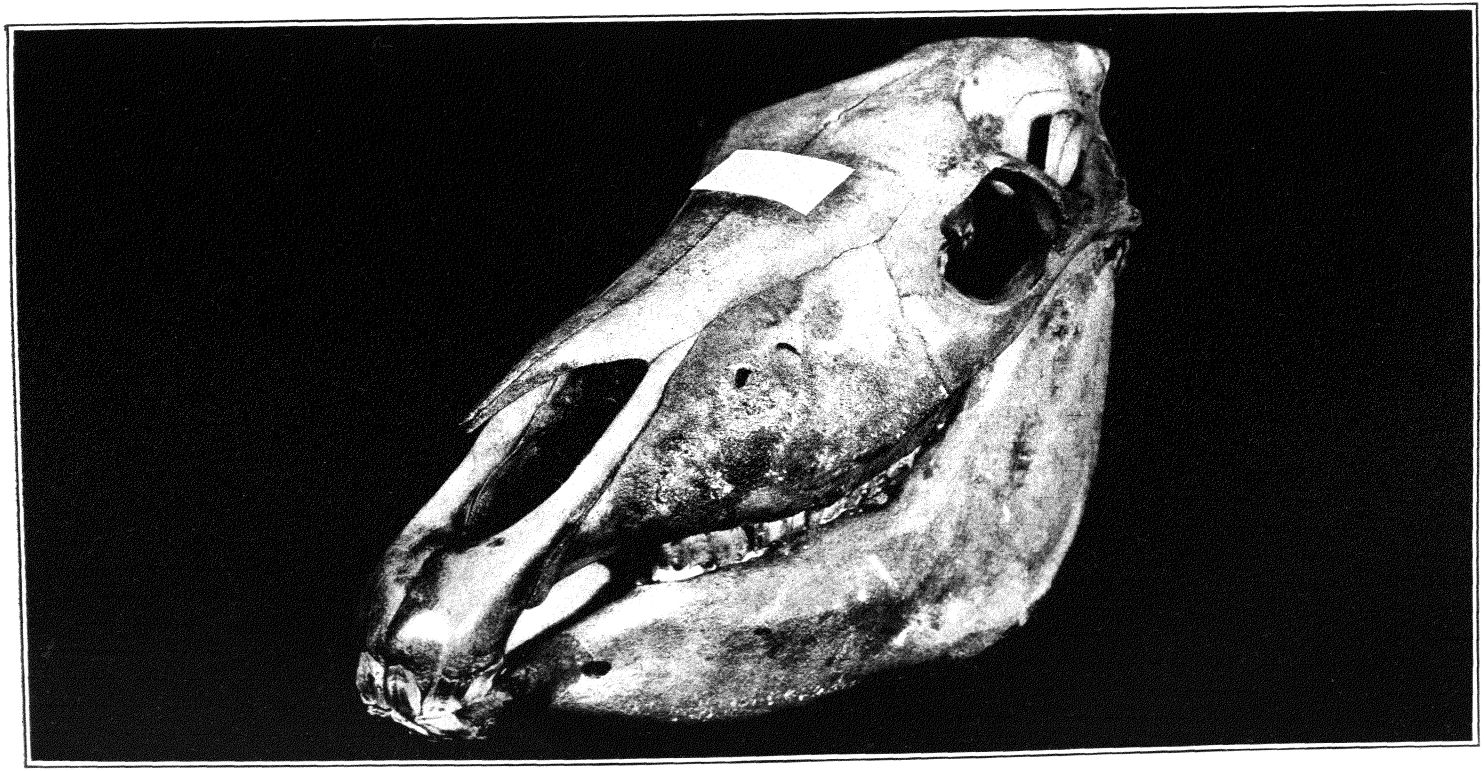

PLATE 11. SKULL.

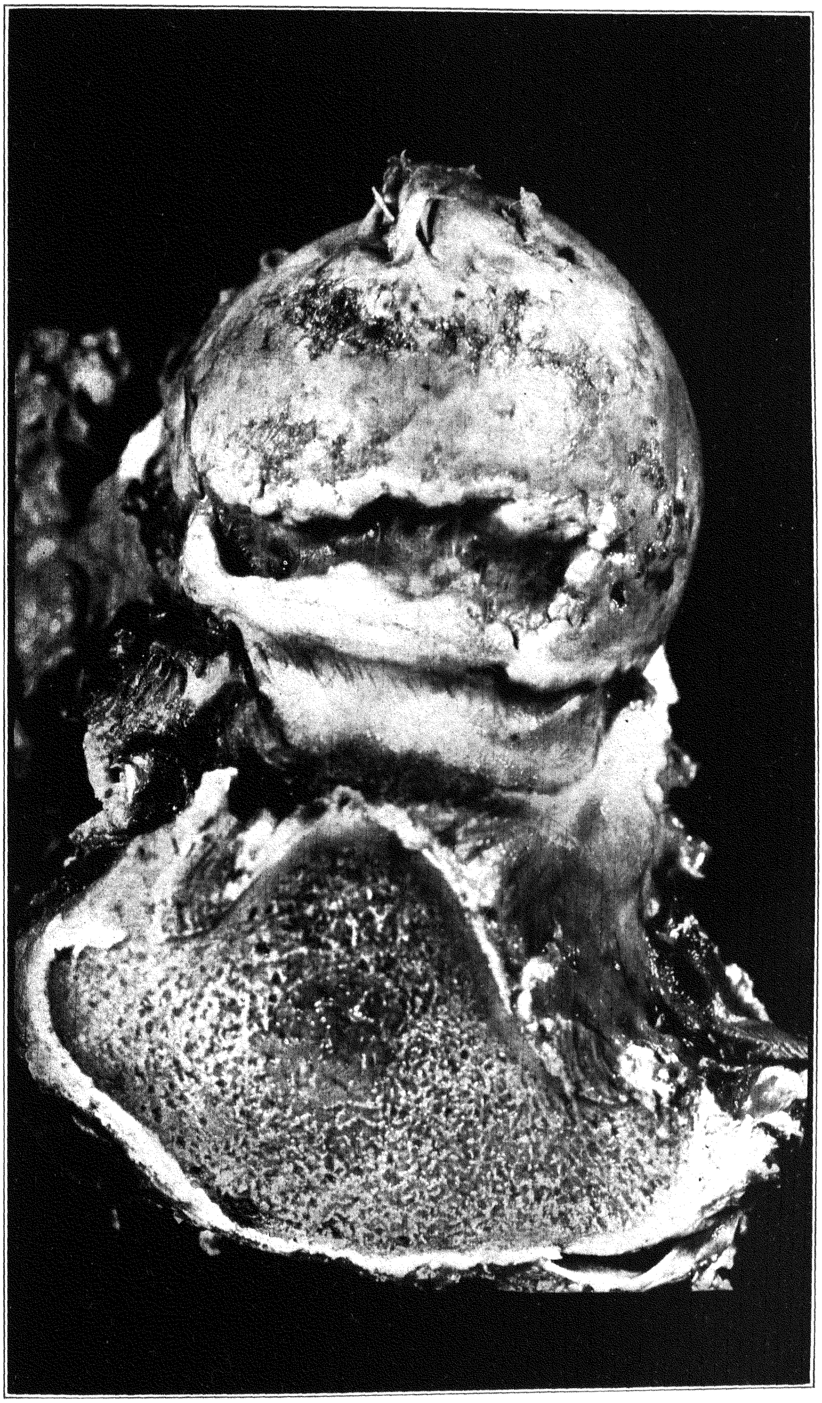

PLATE 12. HEAD OF FEMUR.

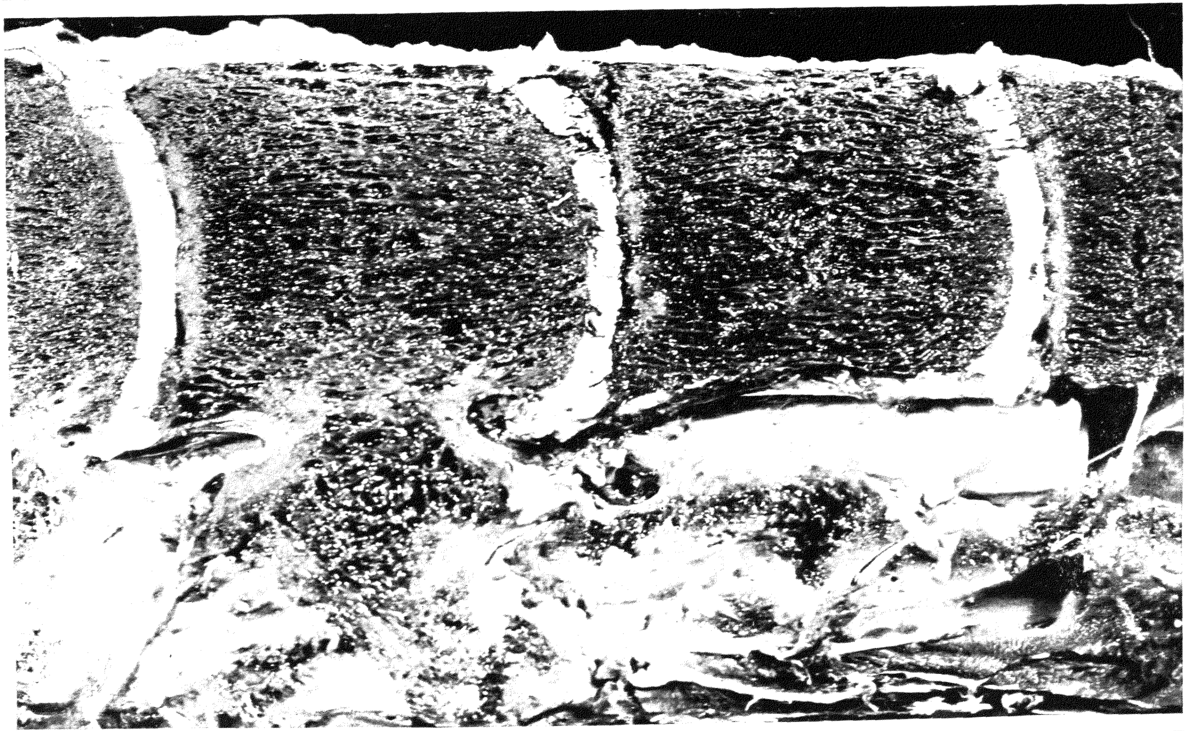

PLATE 13. CROSS SECTION OF VERTEBRAE

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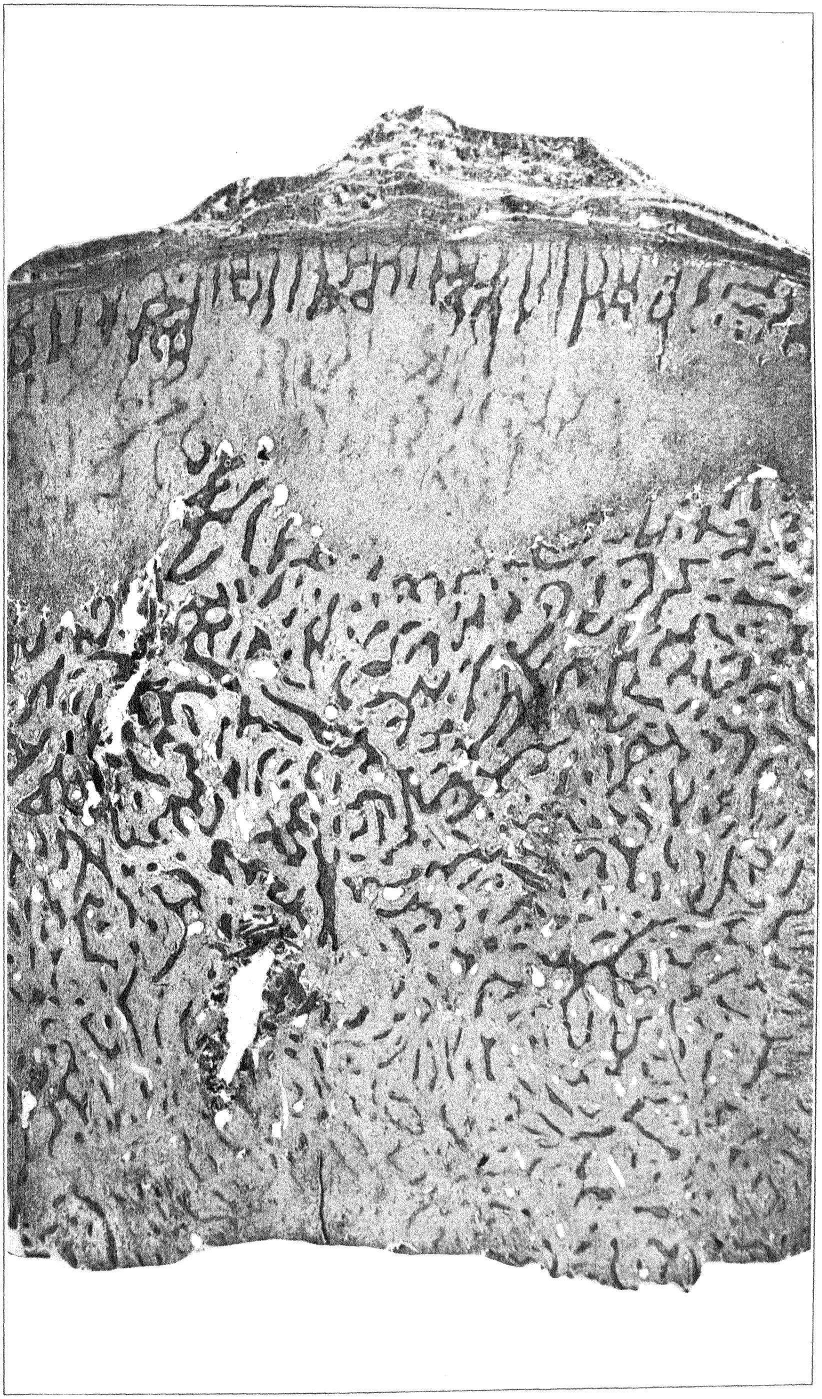

PLATE 14. JAW.

UNIV. OF MICH.

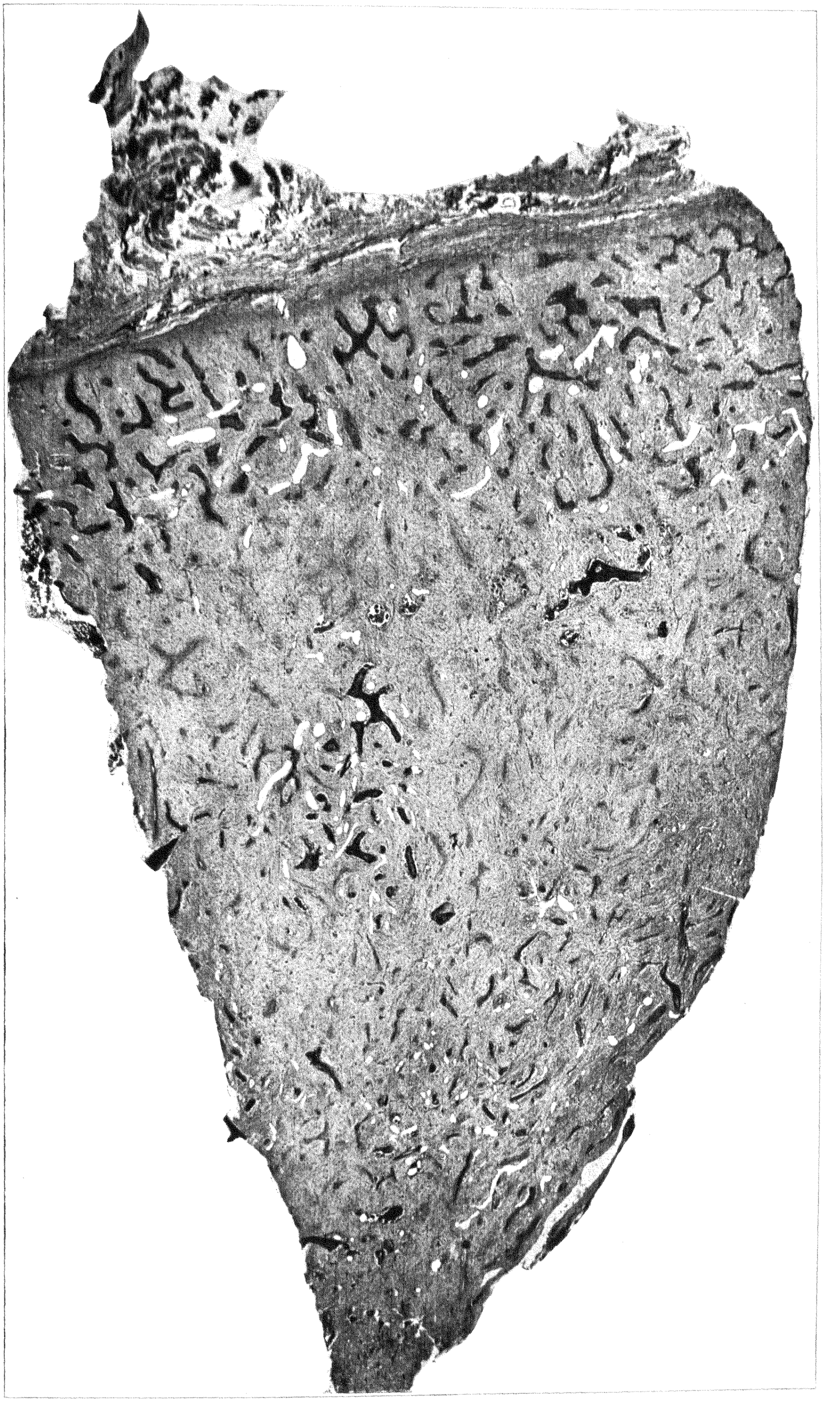

PLATE 15. JAW.

UNIV. OF MICH.

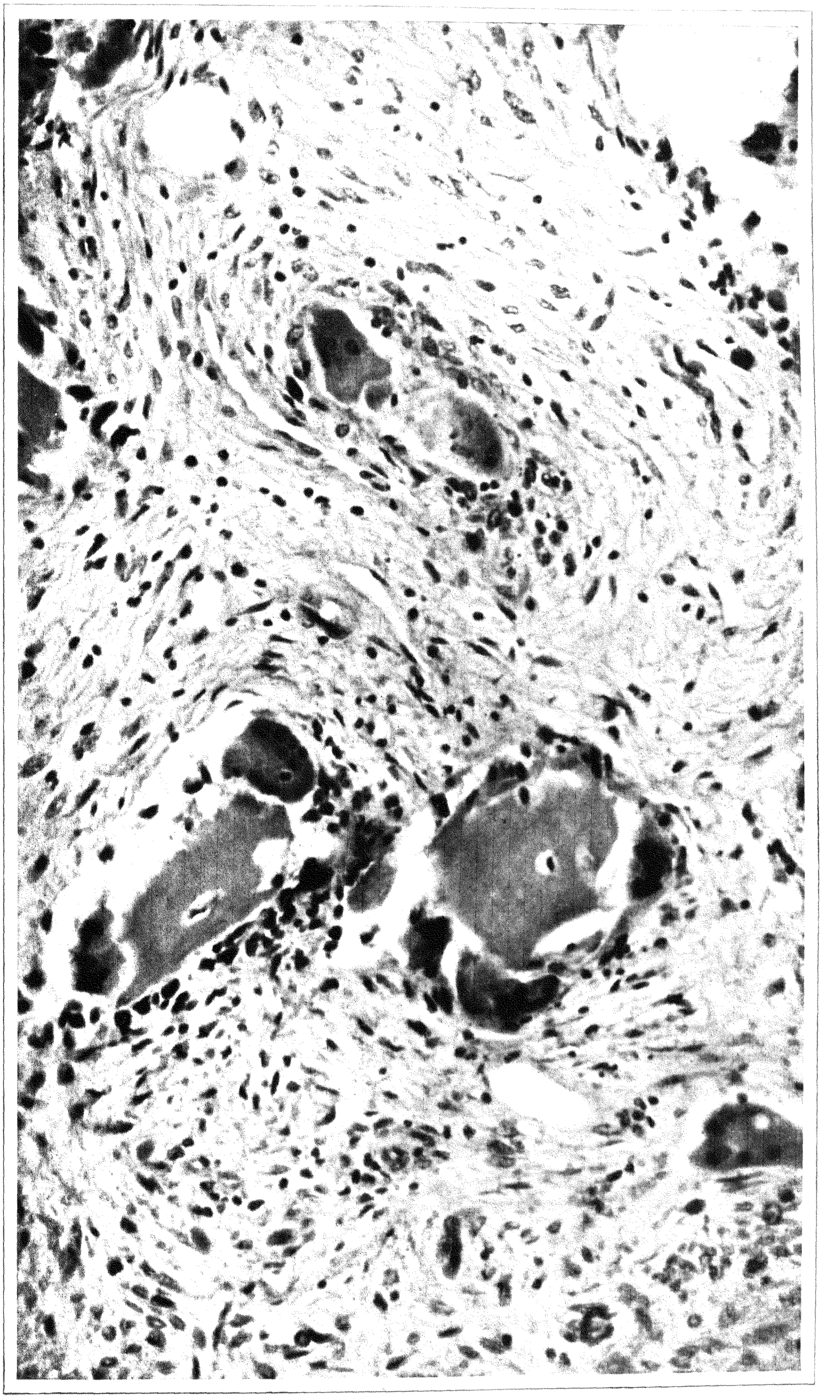

PLATE 16. MAXILLA.

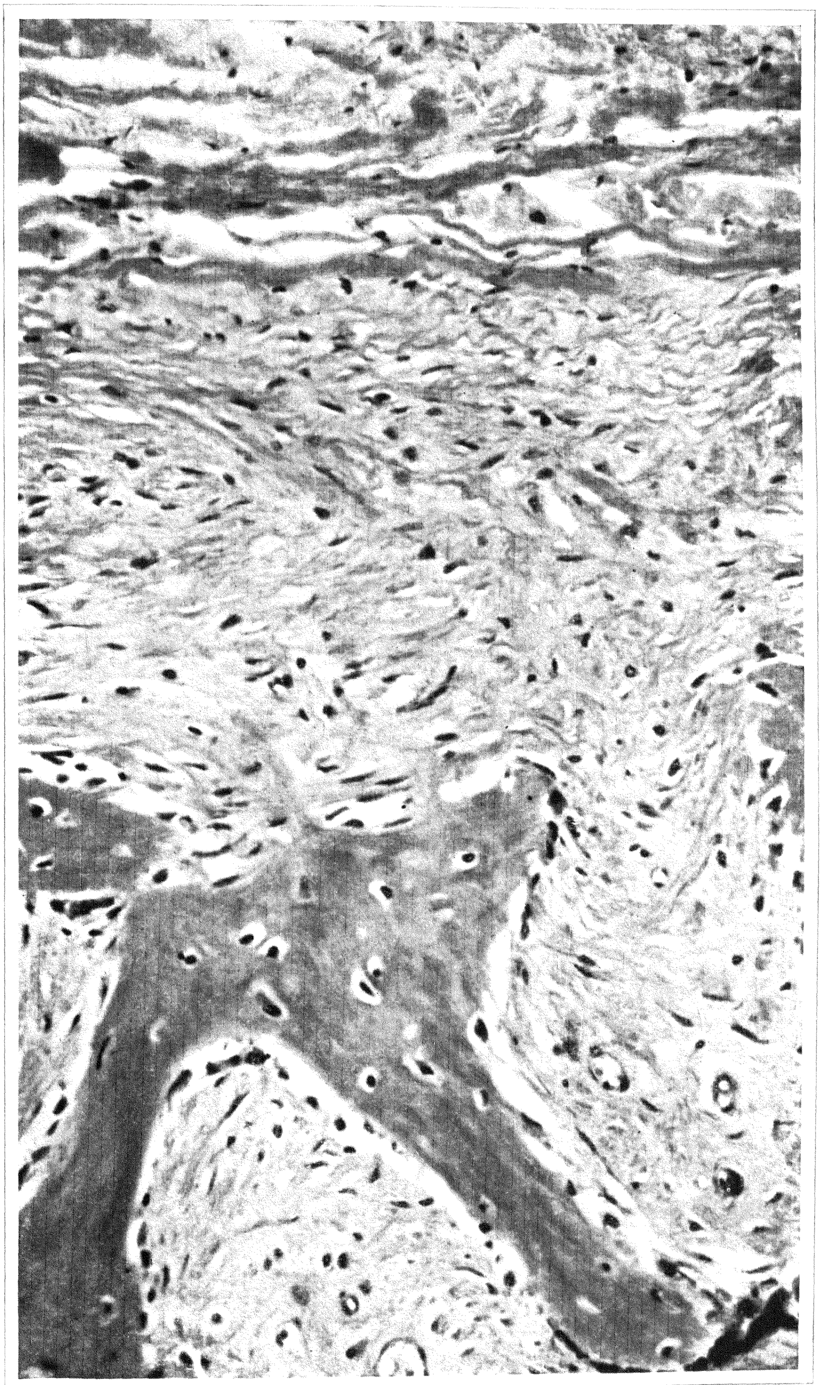

PLATE 17. MAXILLA.

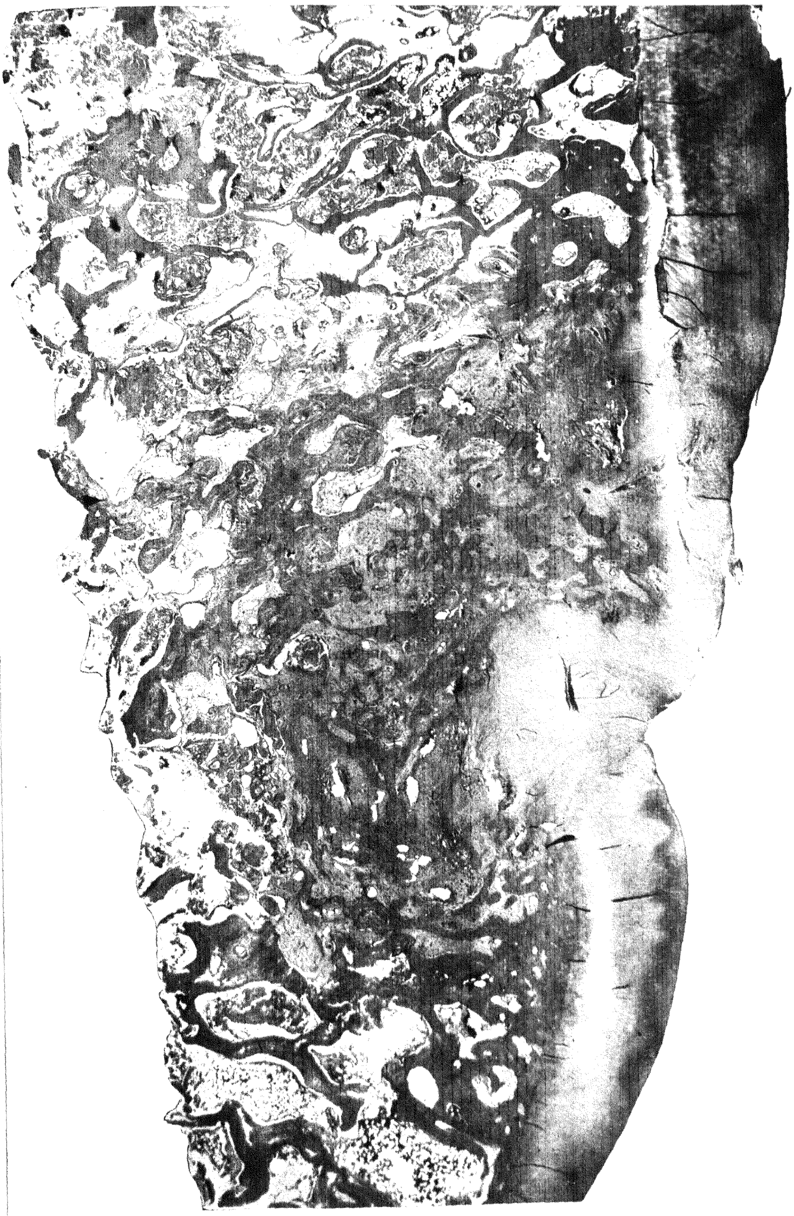

PLATE 18. HEAD OF FEMUR.

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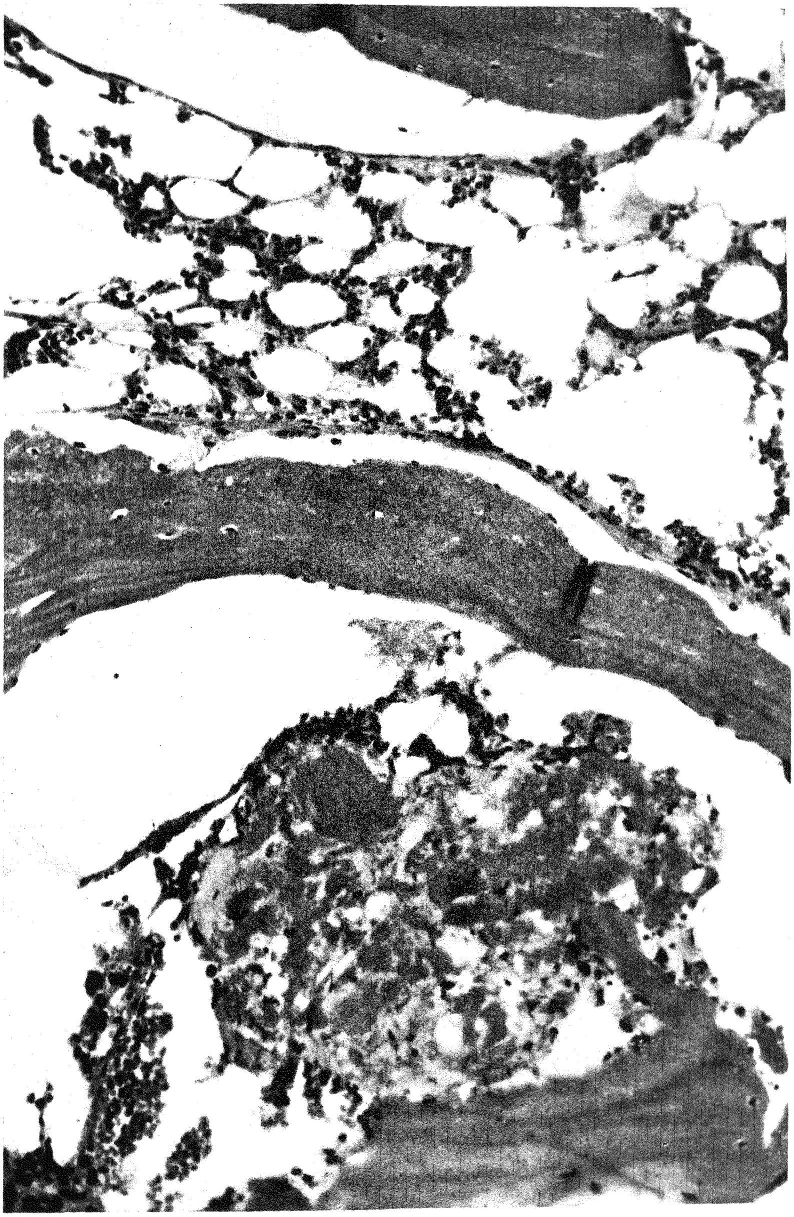

PLATE 19. HEAD OF FEMUR.

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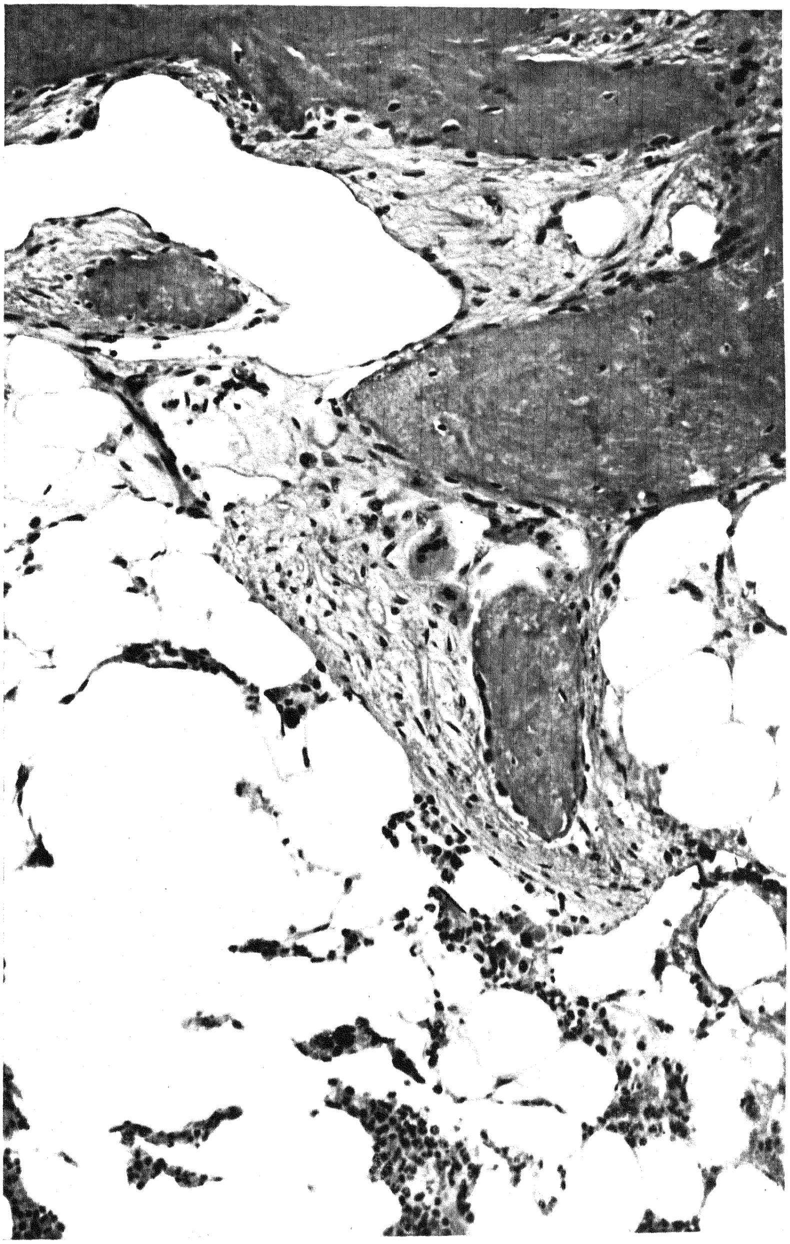

PLATE 20. HEAD OF FEMUR.

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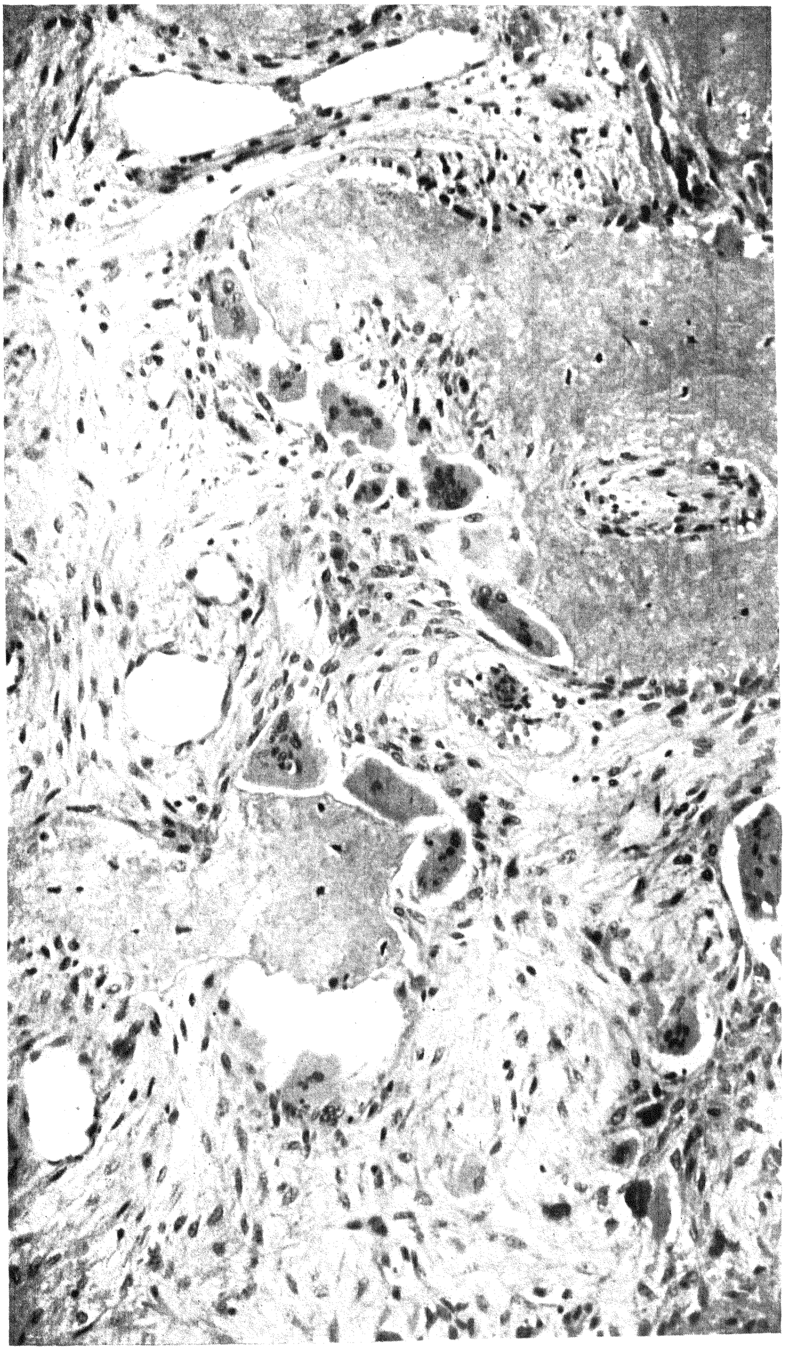

PLATE 21. HEAD OF FEMUR.

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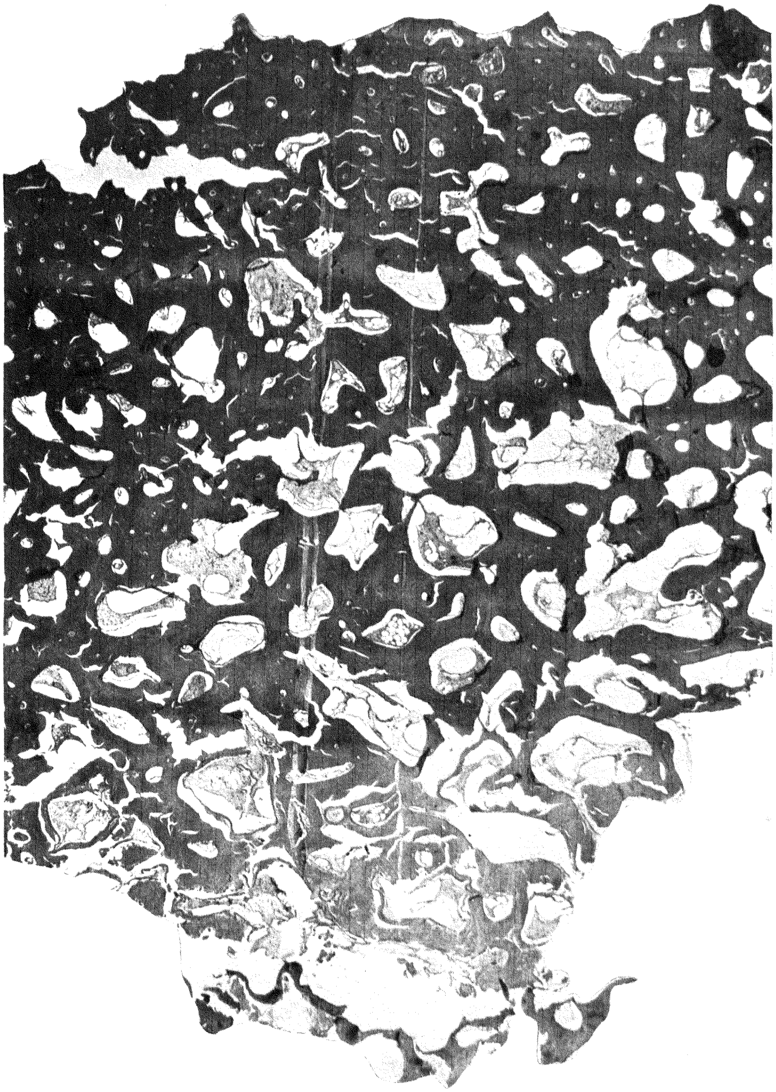

PLATE 22. BONE AND MARROW, LARGE METACARPAL, MIDDLE THIRD.

UNIV. OF MICH.

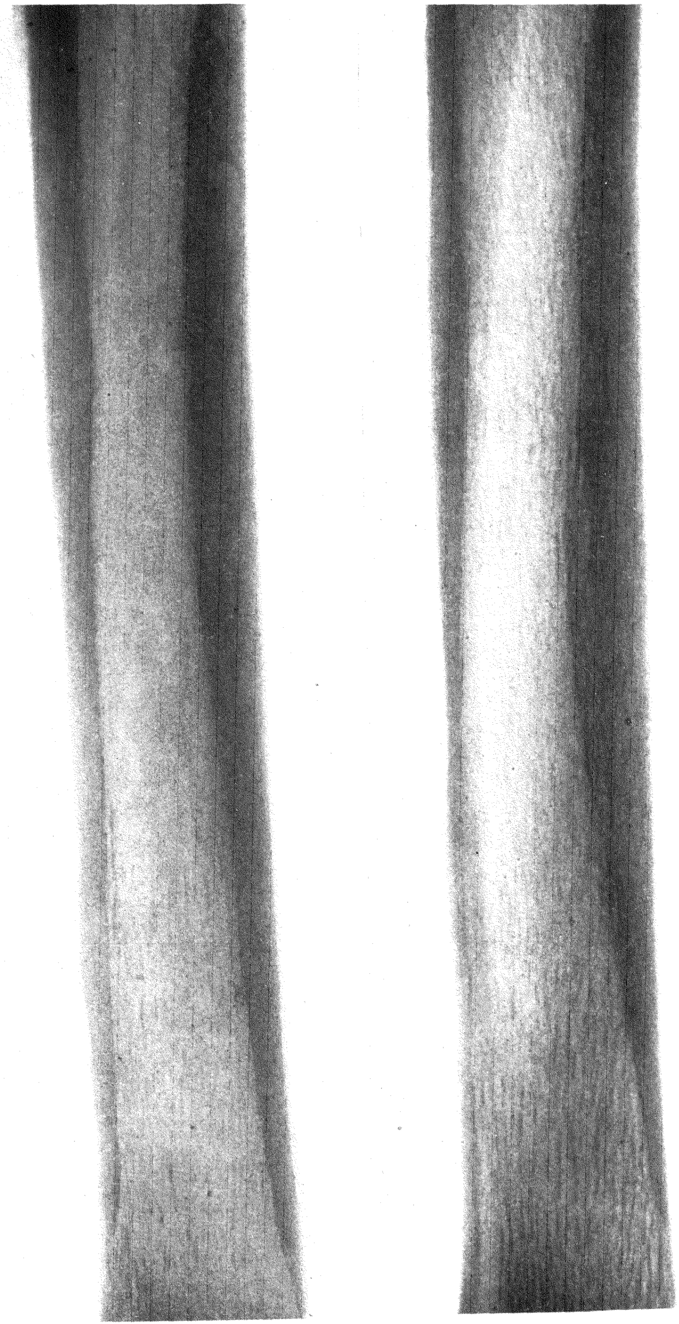

PLATE 23. X-RAY FINDINGS. 1, NORMAL; 2, SLIGHT RAREFACTION.

UNIV. OF MICH.

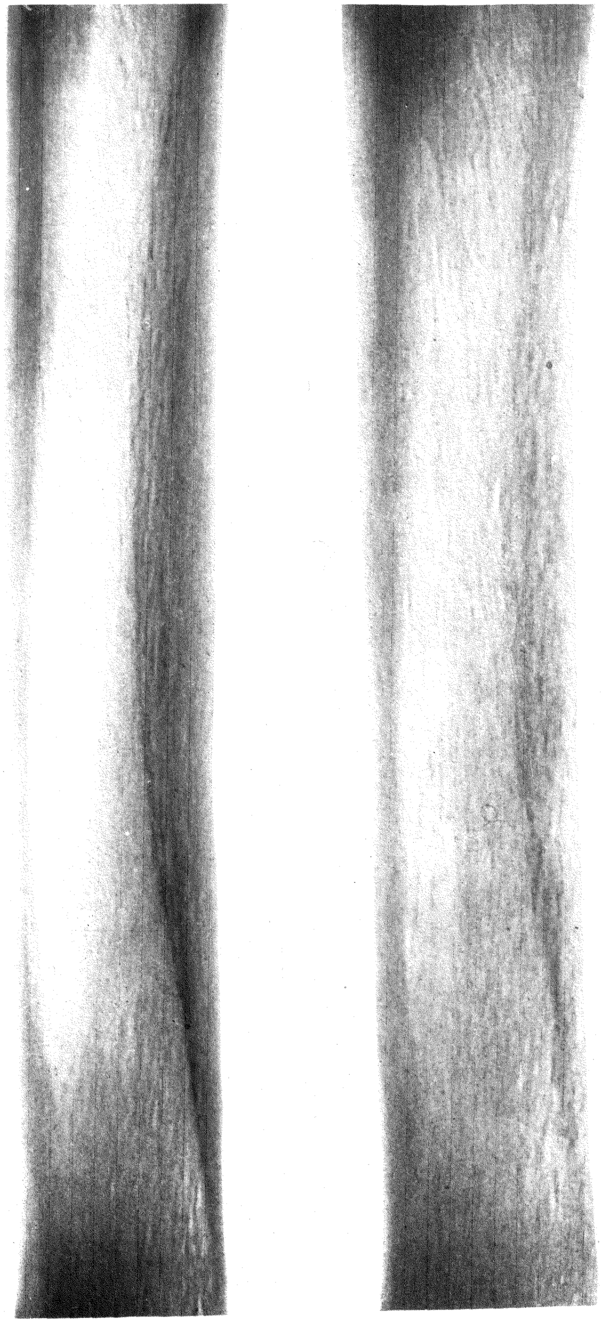

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PLATE 24. X-RAY FINDINGS. 1, MODERATE RAREFACTION; 2, SEVERE RAREFACTION.

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AMBASSIDÆ FROM THE PHILIPPINES

By L. F. DE BEAUFORT

Of Amsterdam, Holland

Through the kindness of Dr. William H. Brown, director of the Bureau of Science, Manila, I have had the opportunity to study a collection of more than one thousand specimens of the genus *Ambassis*.

The collection contains no species previously unknown from the Philippines, excepting *Ambassis miops* Günther. Although there is nothing new in this respect, I have been able, thanks to the large amount of material, to get a better notion of the value of various species. This will be discussed under each species.

In the matter of synonymy I have quoted only the first author and Weber and de Beaufort;[1] full synonymy can be found in the latter work. When it was necessary for the discussion, I have cited more fully.

1. AMBASSIS UROTAENIA Bleeker.

Ambassis urotaenia BLEEKER, Nat. Tijdschr. Ned. Indië 3 (1852) 257.

Priopis lungi JORDAN and SEALE, Bull. Bur. Fish. 26 (1906) (1907) 18.

Ambassis urotaenia DE BEAUFORT, Bijdragen Dierk. afl. 19 (1913) 112.

Ambassis urotaenia WEBER and DE BEAUFORT, 404.

Localities.—Vigan, Ilocos Sur Province; Buyon River, Polillo; Lake Taal and Batangas, Batangas Province; Puerto Galera and Pinamalayan, Mindoro; Arimbay River and Bigaa, Albay Province; Bacon and Bulan, Sorsogon Province; Despujols, Tablas; Bantayan, Cebu Province; Loay, Bohol; Lazi, Siquijor; Culion and Balabac Islands, Palawan Province; Placer, Agusan River, Cagayan, Zamboanga, Caldera Bay, and Davao, Mindanao.

As I have already explained[2] *Ambassis lungi* is a synonym of this species. The large amount of material from the Philippines has convinced me further that my former opinion was right.

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[1] Fishes of the Indo-Australian Archipelago 5 (1929).

[2] Loc. cit.

Ambassis urotaenia and the following species are easily distinguished from the others by having only 8 to 9 scales between nape and dorsal. It is characterized by having only one row of scales on the cheeks. It has a wide distribution in Indic and Western Pacific waters.

2. AMBASSIS KOPSI Bleeker.

Ambassis kopsii BLEEKER, Nat. Tijdschr. Ned. Indië 15 (1858) 253.
Ambassis kopsi WEBER and DE BEAUFORT, 405.

Localities.—Paombong, Bulacan Province; Orani, Bataan Province; Malabon, Rizal Province; Manila; Cavite, Cavite Province; Mangarin, Mindoro; Catbalogan, Samar; Estancia and Dumangas, Iloilo Province; Polo Plantation, Oriental Negros Province; Guinlo and Balabac, Palawan Province; Buan Island, Sulu Archipelago. There were also specimens from Sandakan, Borneo, in the collection.

This species, which is easily distinguished from *A. urotaenia* by the greater depth of the head, by having two rows of scales on the cheeks, and by the black tip of the spinous dorsal, has a very small habitat in comparison with the former, as it is only known from Singapore, Banks, Borneo, and the Philippines, including Palawan and Sulu Archipelago.

3. AMBASSIS COMMERSONI Cuvier and Valenciennes.

Ambassis commersonii CUVIER and VALENCIENNES, Hist. Nat. Poissons 2 (1828) 176.
Ambassis commersoni WEBER and DE BEAUFORT, 406.

Localities.—Buguey, Cagayan Province; Vigan, Ilocos Sur Province; Iba, Zambales Province; Lake Taal, Batangas Province; Camarines Sur Province; Baco River, Mindoro; San Jose de Buenavista, Antique Province; Agusan River, Zamboanga, Mindanao River, Cotabato, and Davao, Mindanao.

Ambassis commersoni is very close to *A. miops,* and after having examined the extensive material from the Philippines, I am not sure that they are distinct. Both belong to a group of species in which the linea lateralis is constantly continuous. They differ chiefly in the number of scales between nape and dorsal, which is always greater than in the two preceding species and amounts to 17 to 22 in *A. commersoni* and 12 to 16 in *A. miops.* Furthermore, the maxillary is somewhat dilated distally and emarginated posteriorly in *A. commersoni,* whereas the maxillary of *A. miops* is obliquely truncated behind and scarcely dilated. In this way it is rather easy to distinguish between typical specimens of *A. commersoni* and of *A. miops,* but we found also specimens with 16 or 17 scales before the dorsal and with a maxillary that stands in shape between those of the two species. For discussion see the next following species.

4. AMBASSIS MIOPS Günther.

Ambassis miops GÜNTHER, Proc. Zool. Soc. London (1871) 655.
Ambassis miops WEBER and DE BEAUFORT, 408.

Localities.—Bauang River, La Union Province; Buyon River, Polillo; Cavite, Cavite Province; Lake Taal and Pansipit River, Batangas Province; Baco, Lapog, Bato, and Naujan Rivers, and Butas, Mindoro; Arimbay River and Bigaa, Albay Province; Bacon, Sorsogon Province; Sibuyan, Romblon Province; Dumarao, Capiz Province; Dumaguete and Zamboanguita, Oriental Negros Province; Anajauan, Leyte; Malampaya Sound and Balabac, Palawan Province; Cagayan, Zamboanga, Mindanao River, and Davao, Mindanao.

As said above, some specimens are intermediate between this species and *A. commersoni*. *Ambassis commersoni* is distributed from Madagascar and the east coast of Africa to New Guinea and North Australia, *A. miops* from Madras to Rara Tonga. It may be that they consist of the western and eastern subspecies of the same species, but it may just as well be that the two have not always been distinguished and that both occur in the whole area. It is possible that Bleeker has mixed these two species, for in his description of *A. commersoni*[3] he mentions about 13 scales before the dorsal (which would point to *A. miops*), whereas we found 18 to 20 prædorsal scales in the specimens of Bleeker's collections in the Leiden Museum, labelled by him *A. commersoni*. *Ambassis miops* is not mentioned by Bleeker in the Atlas. If further investigations show that really *A. miops* is absent from the western part of the Indic, and that *A. commersoni* does not reach so far into the Pacific as *A. miops*, I think the only explanation possible is that they hybridize where they occur together. We will meet with more species of *Ambassis* that seem to merge into each other.

A third species of this group, *A. nalua*, has been recorded from the Philippines by Bleeker, but I did not find it in the material sent to me. It may be distinguished from *A. miops* and *A. commersoni* by having the maxillary much more dilated posteriorly than *A. commersoni* and by having only 12 or 13 prædorsal scales.

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[3] Atlas Ichthyologique 8: 136.

5. AMBASSIS GYMNOCEPHALUS (Lacépède).

Lutjanus gymnocephalus LACÉPÈDE, Hist. Nat. Poissons 3 (1802) pl. 23. fig. 3; 4 (1802) 216.

Ambassis gymnocephalus WEBER and DE BEAUFORT, 412.

Localities.—Malabon, Rizal Province; Tondo Market, Manila; Lake Taal, Batangas Province; San Miguel Bay, Camarines Sur Province; Catbalogan, Samar; Carigara, Leyte; Bantayan, Cebu Province; Guimaras Strait. There are further specimens in the collection from Sandakan, Borneo, and from Amoy and Hong Kong.

Ambassis gymnocephalus is easily distinguished by its interrupted lateral line and having more than one spine on the supraorbital ridge. This ridge is smooth excepting a posterior terminal spine in all species of *Ambassis* known to me, but in *gymnocephalus* it is preceded by one, two, or three spines. As Weber and de Beaufort have remarked before, *A. gymnocephalus* is closely related to *A. buruensis.* In the material from the Philippines I found several specimens in which one of the supraorbital ridges had only a terminal spine, whereas the other had two spines. As there are no other salient differences between *A. gymnocephalus* and *A. buruensis* (the difference in depth is not constant), I am at a loss how to decide whether these specimens belong to *gymnocephalus* or to *buruensis.* Here, again, the possibility of interbreeding may be thought of.

6. AMBASSIS INTERRUPTA Bleeker.

Ambassis interrupta BLEEKER, Nat. Tijdschr. Ned. Indië 3 (1852) 696.

Priopis buruensis JORDAN and SEALE, Bull. Bur. Fish. 26 (1906) (1907) 18.

Ambassis interrupta WEBER and DE BEAUFORT, 415.

Localities.—Agno River, Pangasinan Province; Subic, Zambales Province; Guagua and Pilipit Creek, Pampanga Province; Orani and Pilar, Bataan Province; Buyon River, Polillo; Malabon, Rizal Province; Pasig River, Bureau of Science fishpond, and Manila markets, Manila; Cavite, Cavite Province; Balanak River, Laguna Province; Laguna de Bay; Pansipit River, Batangas Province; Arimbay River and Bigaa, Albay Province; Bato River, Mindoro; Anajauan, Leyte; Agusan River, Cagayan, Zamboanga, and Davao, Mindanao; Balabac, Palawan Province; Malum River and Tawitawi, Sulu Archipelago; and further specimens from Hong Kong.

As mentioned by Jordan and Richardson,[4] *buruensis* and *interrupta* are hardly distinguishable. The difference between these two species is, that in *A. interrupta* the border of the interoperculum is toothed, whereas it is smooth or with a single spine in *buruensis*. Here, too, we find all kinds of gradations between specimens with well-developed spines and others with these spines almost obsolete. This is no matter of age, as some very small specimens have strong teeth and others, equally small, have none.

There is not much difference between the range of these two species. *Ambassis interrupta* covers a somewhat larger area, being known from the Andamans, the Indo-Australian Archipelago, the Philippines, and New Caledonia. *Ambassis buruensis* is only known from the Indo-Australian Archipelago and the Philippines. This shows the improbability of the differences between the two being due to sex.

7. AMBASSIS BURUENSIS Bleeker.

Ambassis buruensis BLEEKER, Nat. Tijdschr. Ned. Indië 11 (1856) 396.

Ambassis buruensis WEBER and DE BEAUFORT, 417.

Localities.—Bauang River, La Union Province; Subic, Zambales Province; Pasig River, Manila; Lake Taal, Pansipit River, and Balayan Bay, Batangas Province; Baco and Naujan Rivers, Mindoro; Arimbay River and Bigaa, Albay Province; San Jose de Buenavista, Antique Province; Cabalian, Leyte; Dumaguete, Oriental Negros Province; Lazi, Siquijor; Cagayan, Agusan River, and Caldera Bay, Mindanao.

We have seen that *A. buruensis, A. interrupta,* and *A. gymnocephalus* are closely allied species. They have in common the interrupted linea lateralis. *Ambassis buruensis* is the less "spiny" of the three, having neither spines on the supraorbital ridge nor on the lower border of the interoperculum, but we have seen that in some specimens two spines may occur on the supraorbital ridge, and that in others traces of spines on the interoperculiar border may be found. In one direction *A. buruensis* seems to vary towards *A. gymnocephalus,* in the other towards *A. interrupta.* In this respect it is interesting to remember that Weber and de Beaufort[5] record a specimen of

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[4] Bull. U. S. Bur. Fish. 27 (1907) (1908) 255.

[5] Op. cit. 413, footnote.

A. gymnocephalus of unknown locality, with a serrated interoperculum. Thus, we have seen specimens combining the characters of *buruensis* and *interrupta,* of *buruensis* and *gymnocephalus,* and of *gymnocephalus* and *interrupta.*

Of the three species *A. gymnocephalus, A. buruensis,* and *A. interrupta,* the first has by far the largest distribution, ranging from the coast of East Africa to the north coast of Australia. We have seen that the range of *interrupta* and *buruensis* is almost restricted to the Indo-Australian Archipelago and its neighborhood. Might it be possible that the occurrence here in coastal and brackish waters of isolated islands has promoted the origin of different strains?

SOME STUDIES IN THE LARVICIDAL EFFECTS OF ARSENICALS OTHER THAN PARIS GREEN AGAINST ANOPHELES LARVÆ

LARVICIDE STUDIES, III[1]

By Paul F. Russell

Of the International Health Division of the Rockefeller Foundation

and

Augustus P. West

Of the Bureau of Science, Manila

The following studies are a continuation of those reported in our first two papers.[2] These experiments are being made in an attempt to reduce the cost of malaria control as regards larvicidal measures, possibly by finding a cheaper poison than Paris green, perhaps by making it possible to lessen the amount necessary to be effective, or by devising more-efficient measures of application.

In the first paper the use of powdered charcoal as a diluent for Paris green was considered. In the second paper laboratory experiments were reported in which Paris green partially adsorbed on charcoal in various concentrations and combinations, was tried. In this paper arsenicals other than Paris green are considered. The results obtained indicate that, as a mosquito larvicide, Paris green is more efficient than the other arsenical preparations we used. This suggests that the copper in Paris green has a real influence in the excellent larvicidal effects of this substance.

EXPERIMENTAL PROCEDURE

The method of preparing the charcoal larvicides and the technic employed in using them have been discussed in our previous papers. It is obviously important that standardized methods be used if valid comparisons are to be made. Consequently care has been taken to follow a given procedure in all experiments.

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[1] These studies were undertaken by the divisions of organic chemistry and of malaria investigations, Bureau of Science. The division of malaria investigations is coöperatively supported by the Bureau of Science and by the International Health Division of the Rockefeller Foundation.

[2] Russell, P. F., and A. P. West, Philip. Journ. Sci. 48 (1932).
West, A. P., and P. F. Russell, Philip. Journ. Sci. 48 (1932).

Only third- and fourth-stage anopheles larvæ were used, chiefly of the species *Anopheles subpictus* and *A. hyrcanus* var. *sinensis.* Artesian water was placed in enamel pans so that the surface area was approximately 532 square centimeters and the depth 5 centimeters. Larvæ were not removed as dead until they failed to respond to stimulation, all motion having ceased. They were then transferred to beakers of water for observation to insure against mistakes in diagnosis of death-point or in counting. Comparable amounts of larvicide were used, and the weight in grams is given in the tables.

RESULTS

In Table 1 are presented the results of some tests of the larvicidal properties of arsenic trioxide adsorbed on charcoal. These experiments were made to find out if this simple arsenical in combination with charcoal will poison larvæ as effectively as Paris green. The latter contains copper as well as arsenic and is consequently more expensive.

These tests, when compared with those of Paris green (see our second paper, Tables 1 to 5) show plainly that Paris green is more effective than arsenic trioxide. Not until the concentration of arsenic trioxide reached 8.5 per cent (tests 2, 51, and 68) did the larvicide kill 100 per cent of the larvæ in twenty-four hours. Even concentrations as high as 10 per cent (tests 3, 13, and 52) failed to eliminate the larvæ completely.

Incomplete effect was also seen when the arsenic trioxide was mechanically mixed with charcoal as a diluent in a 1 per cent concentration (test 85). These results are in line with those of Barber and Hayne.[3] In Table 2 are presented the results of tests in which lime, borax, or sodium carbonate, in addition to arsenic trioxide, were adsorbed on charcoal. Here again the results are notably less satisfactory than when Paris green was used in similar combinations as shown in our second paper.

This is suggestive evidence that the copper in the Paris green has a real influence in the larvicidal effects of this substance. Such a suggestion is not original but has been broached by others. For example, Williams in discussing a paper by Ginsburg[4] refers to this possibility.

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[3] U. S. Pub. Health Rep. 36, No. 49 (1921) 3028.

In Table 3 are shown the results of tests with miscellaneous arsenical preparations adsorbed on charcoal in various combinations and concentrations. Only zinc arsenite (test 156) gave results comparable to Paris green.

It is interesting that atoxyl (test 106), arsenic pentoxide (test 88), and salvarsan (tests 104 and 105) were relatively harmless.

It is surprising that such highly toxic substances as barium arsenite (test 31) and lead arsenite (test 62) were comparatively harmless to anopheles larvæ in concentrations equal to or greater than those which in the case of Paris green were lethal for the larvæ. This, however, simply confirms the results of Barber and Hayne. Tannic acid in combination with arsenic trioxide (test 58) was ineffective.

In all of these experiments the larvæ had no difficulty in filling their digestive tract with the charcoal, and after one to two hours the tract was continuously filled with this material for twenty-four hours; in some cases, for seventy-two hours, as in tests 31 and 58.

SUMMARY

Some experiments are reported dealing with the larvicidal effects of certain arsenicals, other than Paris green, when applied to charcoal. These studies confirm the belief that Paris green is the arsenical larvicide par excellence.

The fact that Paris green is more efficient, as a mosquito larvicide, than other arsenical preparations suggests that the copper in Paris green has a real influence in the excellent larvicidal effects of this substance.

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[4] Proc. 15th Ann. Meeting New Jersey Mosquito Extermination Assoc., New Brunswick, N. J. (1928) 63.

TABLE 1.—*Larvicidal effects of arsenic trioxide partially adsorbed on charcoal.*

Test No.	Substances used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																			Weight of larvicide.
				Minutes.								Hours.											
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	7	24	48	72	
		Per cent.																			*g.*
57	Nothing (control)	----	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	----	----
53	Arsenic trioxide	0.55	50	0	0	0	0	2	2	2	2	2	2	2	2	2	----	16	----	----	0.13
1	do	7.0	50	0	0	0	0	0	2	2	4	12	18	46	58	72	----	88	----	----	0.13
2	do	8.5	50	0	0	2	2	6	8	16	28	38	60	78	80	82	----	92	----	----	0.13
51	do	8.5	50	0	0	2	4	8	26	42	54	64	74	92	96	96	----	100	----	----	0.13
68	do	8.5	51	0	0	0	0	2	2	4	8	10	20	24	28	36	----	88	----	----	0.13
3	do	10.0	50	0	0	2	2	6	6	20	32	44	64	84	86	92	----	98	----	----	0.13
13	do	10.0	50	0	0	2	2	2	2	2	8	12	18	44	56	64	----	90	----	----	0.01
52	do	10.0	50	0	0	0	2	2	8	14	20	22	26	38	56	62	----	94	----	----	0.13
[a] 83	Arsenic trioxide Charcoal 1/1000 } mixture	0.1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	----	----	0.1
[a] 84	Arsenic trioxide Charcoal 1/200 } mixture	0.5	50	0	0	0	0	0	0	2	2	4	4	6	14	16	22	24	----	----	0.1
[a] 85	Arsenic trioxide Charcoal 1/100 } mixture	1.0	50	0	0	0	0	0	2	4	6	14	16	16	20	24	34	72	----	----	0.1

[a] In tests 83, 84, and 85 the arsenic trioxide powder was mixed with the charcoal and not adsorbed on it.

TABLE 2.—*Larvicidal effects of arsenic trioxide and lime, borax, or sodium carbonate partially adsorbed on charcoal.*

Test No.	Substances used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																	Weight of larvicide.
				Minutes.								Hours.									
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	7	24	48	72	
		Per cent.																			*g.*
38	Nothing (control)	----------	50	0	0	0	0	0	0	0	0	0	0	0	0	0	----	0	0	0	----------
66	Arsenic trioxide Lime	4.0 1.0	50	0	0	0	0	0	2	2	2	6	12	16	40	46	46	54	----	----	0.1281
74	Arsenic trioxide Lime	4.0 1.0	49	0	0	0	0	0	2	10	16	16	30	32	42	56	----	76	----	----	0.1281
46	Arsenic trioxide Lime	8.0 1.0	50	2	4	4	8	16	22	28	40	44	52	60	74	80	----	98	----	----	0.1281
47	Arsenic trioxide Lime	10.0 1.0	50	0	2	2	4	4	14	22	28	30	34	40	52	58	----	94	----	----	0.1281
67	Arsenic trioxide Sodium carbonate	4.0 1.0	50	0	0	0	0	0	0	0	2	2	2	2	4	6	6	6	----	----	0.1281
75	Arsenic trioxide Sodium carbonate	4.0 1.0	47	0	0	0	0	0	0	2	2	2	6	16	24	30	----	45	----	----	0.1281
101	Arsenic trioxide Borax	0.8 0.4	50	0	0	0	0	0	0	0	0	0	0	0	0	0	6	8	----	----	0.1
76	Arsenic trioxide Borax	1.0 1.8	50	0	0	0	0	0	0	0	0	0	0	0	0	----	----	4	----	----	0.1

TABLE 3.—*Larvicidal effects of miscellaneous arsenical substances partially adsorbed on charcoal.*

Test No.	Substances used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																	Weight of larvicide.
				Minutes.								Hours.									
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	7	24	48	72	
		Per cent.																			*g.*
119	Nothing (control)	----	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	----
158	do	----	50	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	----	----	----
4	Arsenic brom phenol	3.0	50	0	0	0	0	0	0	0	0	0	0	0	0	2	----	4	----	----	0.13
106	Atoxyl	0.5	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	----	----	0.1
105	Salvarsan	0.2	50	0	0	0	0	0	0	0	0	0	0	----	----	----	----	0	----	----	0.1
104	Salvarsan Borax	0.2 0.4	50	0	0	0	0	0	0	0	0	0	0	----	----	----	----	0	----	----	0.1
120	Arsenic trioxide Copper carbonate	0.5 0.05	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	----	----	0.1
77	Arsenic trioxide Borax Lime	1.0 1.0 1.3	50	0	2	2	2	2	2	2	2	2	2	2	4	----	----	22	----	----	0.1
88	Arsenic pentoxide	1.0	50	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	----	----	0.1
111	Arsenic pentoxide Aniline	0.5 2.0	50	0	0	0	0	0	0	0	0	0	0	2	4	6	8	20	----	----	0.1
31	Barium arsenite Lime	3.0 0.5	50	0	2	2	2	2	2	2	2	2	2	2	2	2	----	2	2	2	0.13
116	Barium arsenite Ammonium chloride	0.5 1.5	50	0	0	0	0	0	0	0	0	0	0	0	0	0	----	8	----	----	0.1
42	Calcium arsenite Lime	3.0 0.5	50	0	0	0	0	0	0	0	0	0	2	2	2	2	----	2	----	----	0.13
43	Nickel arsenite Lime	3.0 0.5	50	0	0	0	0	0	2	2	2	2	2	2	10	16	----	48	----	----	0.13
62	Lead arsenite	7.6	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	----	----	0.13

58	Arsenic trioxide Tannic acid	2.0 1.0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	----	10	10	10	([a])
[b] 87	Arsenic trioxide Borax-charcoal 1/100	1.0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	----	----	0.1
121	Potassium arsenite Copper sulphate	0.075 0.125	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	----	----	0.1
156	Zinc arsenite	2.0	50	0	0	0	0	0	0	4	4	14	28	70	82	82	98	98	----	----	0.1

[a] To cover surface.

[b] No. 87 was a mixture.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), X[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

THREE PLATES

The Chinese Tipulidæ discussed at this time were chiefly contained in extensive collections made in Szechwan by Mr. Franck and received through the kind interest of Mr. Herbert S. Parish. One additional Chinese species was collected by Prof. Claude R. Kellogg, now at the Massachusetts State College. The more-numerous Japanese crane flies discussed herewith were included in extensive collections made by Messrs. Imanishi, Inomata, Hibi, Kamiya, Machida, Sakaguchi, and Tokunaga. I am very greatly indebted to all of the above-mentioned entomologists for their continued interest in making known the Tipulidæ of China and Japan, and for the privilege of retaining the types in my collection.

TIPULINÆ

DOLICHOPEZA (NESOPEZA) FRANCKI sp. nov. Plate 1, fig. 1; Plate 2, fig. 23.

General coloration of mesonotal præscutum brown, with four brownish black stripes; antennæ relatively short; legs pale brown, the tips of femora, and more narrowly of tibiæ, darkened; tarsi white; wings with a grayish tinge; stigma dark brown, preceded and followed by conspicuous whitish areas; abdominal tergites weakly bicolorous, of the sternites more conspicuously so, the incisures blackened; male hypopygium with the lateral angles of the tergite black, the median ventral point small; inner dististyle heavily blackened.

Male.—Length, about 9 to 9.5 millimeters; wing, 9.5 to 10.

Female.—Length, about 11 to 11.5 millimeters; wing, 10.5 to 11.

Frontal prolongation of head and palpi dark brown. Antennæ with the scape and pedicel light yellow; flagellum dark brown; antennæ relatively short, if bent backward extending to shortly beyond wing root. Front and anterior vertex light yellow; remainder of head dark brown, in cases with the pale coloration of the anterior vertex continued caudad onto the central portion of the posterior vertex.

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[1] Contribution from the entomological laboratory, Massachusetts State College.

Mesonotum with the ground color brown, with four brownish black stripes, the intermediate pair more polished, the lateral pair more obscure; remainder of mesonotum blackish, the postnotal mediotergite dusted with gray. Pleura brownish testaceous, the ventral anepisternum, meron, and ventral sternopleurite blackened, more or less pruinose. Halteres pale, the knobs dark brown. Legs with the coxæ brown; trochanters yellow; femora pale basally, passing into brown, the tips brownish black; tibiæ pale testaceous, the tips narrowly darkened; tarsi snowy white, the proximal ends of basitarsi a trifle more obscure. Wings (Plate 1, fig. 1) with a gray suffusion, the prearcular and costal regions somewhat paler; stigma conspicuous, dark brown, preceded and followed by whitish areas, obliterative area crossing the fork of M more restricted in amount; veins brown. Venation: Rs longer than m-cu; forks of medial field relatively shallow; cell 2d A of moderate width.

Abdominal tergites weakly bicolorous, the bases of the individual segments darkest, the remainder of each paler, with the exception of a narrow caudal darkening; sternites more conspicuously bicolorous, the incisures black, the intermediate portions yellow, the basal darkening more extensive than the narrow apex. Male hypopygium (Plate 2, fig. 23) with the lateral angles of the tergite, *9t*, heavily blackened, the median region produced caudad into a small ventral point. Outer dististyle, *od*, relatively long. Inner dististyle, *id*, heavily blackened.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 4,500 feet, August 4, 1930 (*Franck*). Allotopotype, female. Paratopotypes, 3 males and females, July 24 to August 20, 1930.

Dolichopeza (*Nesopeza*) *francki* is respectfully dedicated to the collector, to whom I am greatly indebted for many rare Tipulidæ from western China. It is allied to *D.* (*N.*) *albitibia* (Alexander), of Japan, differing in the coloration of the body, legs, and wings, and the details of structure of the male hypopygium, especially of the tergite and inner dististyle.

TIPULA SETICELLULA sp. nov. Plate 1, fig. 2; Plate 2, figs. 24 to 28.

General coloration of thorax black, the abdomen yellow, the outer segments blackened; wings with the outer radial and medial cells with abundant macrotrichia; r-m connecting with Rs at or shortly before its fork; male hypopygium with the ninth tergite tridentate; eighth sternite with a broad median depressed setiferous lobe.

Male.—Length, about 13 millimeters; wing, 15.

Described from an alcoholic specimen.

Frontal prolongation of head yellowish brown; nasus long and slender; palpi black, the terminal segment paling to yellowish white. Antennæ (male) relatively long, if bent backward extending about to the base of abdomen; scape, pedicel, and first flagellar segment yellow; remaining segments of flagellum weakly bicolorous, the base of each dark brown, the remainder light brown. Head dark, probably with a bloom in dry specimens.

Mesonotum chiefly blackened, the præscutum chiefly covered by the three confluent black stripes; scutal lobes similarly blackened; scutellum obscure yellow, the parascutella dark; postnotum dark. Pleura chiefly dark, the pteropleurite paler; dorsopleural region pale. Halteres pale. Legs with the coxæ yellow, the extreme bases weakly darkened; trochanters yellow; femora yellow, the tips narrowly brownish black, a trifle more extensively so on the forelegs; tibiæ yellowish brown, the tips darkened; tarsi brownish black. Wings (Plate 1, fig. 2) cream-colored, the prearcular and costal regions bright yellow; distal two-thirds of wings gradually darkened, the tip most deeply so; restricted darker areas at origin of Rs and along cord, the latter confluent with the conspicuous stigma; an oblique band of the ground color beyond the stigma, extending from cell R_2 to R_5; less distinct ground areas before stigma and in outer end of cell M; veins brown, flavous in the pale areas. Outer cells of wing with numerous, conspicuous macrotrichia, most extensive in cells R_3 to M_1, with fewer trichia in extreme outer ends of cells 2d M_2 to Cu_1, inclusive. Venation: R_{1+2} entire; Rs long; r-m connecting with Rs at or before the fork of latter; cell 1st M_2 small, pentagonal.

Abdomen yellow, the basal tergites very narrowly trivittate with brown; terminal four segments blackened. Male hypopygium (Plate 2, fig. 24) relatively large, the sutures between tergite, sternite, and basistyle distinct. Ninth tergite (Plate 2, fig. 25) large, not heavily sclerotized, the outer half narrowed, the caudal margin with three lobes, the median lobe smaller and more slender than the laterals, with a sharp median keel on ventral surface; viewed laterally, the outer lobes are deeper and weakly emarginate. Inner and outer dististyles as shown (Plate 2, fig. 26), the former with a glabrous fingerlike lobe on outer margin at base, the latter cylindrical, with long conspicuous setæ. Gonapophyses (Plate 2, fig. 27) bispinous. Eighth sternite (Plate 2, fig. 28) projecting, the margin broadly notched, bearing a broad, depressed-triangular, median lobe that is densely setiferous; lateral portions of emargination, on either side of median lobe, with a small tuft of five or six stouter setæ.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Saga, Kyoto Prefecture, altitude 490 feet, August 5, 1928 (*Tokunaga*).

Tipula seticellula is very different from the other Japanese species of *Tipula* having macrotrichia in the outer cells of the wing, differing especially in venation and the structure of the hypopygium. I am uncertain as to the subgeneric position of the present fly. The recent attempt by Edwards to divide the vast genus *Tipula* into subgeneric groups [2] forms a most important contribution to our knowledge of the subject. However, in any extensive treatment of members of this genus, there will long remain species whose strict assignment in subgenera will be uncertain and which must therefore be left unassigned. A similar case exists in *Limnophila* and other large and involved genera. In the past, certain workers have placed such uncertain forms in the typical subgenus, but such a course should be strictly avoided.

TIPULA (TIPULA) OKINAWENSIS sp. nov. Plate 1, fig. 3; Plate 2, fig. 29.

Allied to *yamata;* mesonotum fulvous-orange; wings yellowish brown, the base and costal region more saturated; Rs short, less than m-cu; male hypopygium with the lobes of the tergite obliquely truncated at tips; outer dististyle conspicuously dilated and bearing numerous setæ on lower margin at near midlength; inner dististyle cultriform.

Male.—Length, about 13 millimeters; wing, 16.5.

Frontal prolongation of head light brown; palpi pale brown. Antennæ brown, the basal enlargements of the individual segments darker; flagellar verticils very long. Front light cream-colored; posterior sclerites of head dark brown.

Mesonotal region fulvous-orange. Pleura pale yellow, variegated with light brown on the dorsopleural region; pteropleurite, ventral sternopleurite, and ventral meron slightly darkened.

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[2] Ann. & Mag. Nat. Hist. X 8 (1931) 73–82.

Halteres with the stem yellow, the knobs dark brown. Legs with the coxæ and trochanters yellow; femora brownish yellow, the tips narrowly darkened; tibiæ and tarsi brown; hind tibia with two very unequal spurs, the longer being twice the shorter. Wings (Plate 1, fig. 3) with a yellowish brown tinge, the base and costal region more saturated; stigma light brown. A few scattered macrotrichia on vein R_4. Venation: Rs short, about four-fifths m-cu; R_{1+2} unusually short, pale, but entire, gently sinuous; petiole of cell M_1 less than one-half m; cell 2d A very narrow, as in the group.

Abdominal tergites brown, the caudal margins of the individual segments narrowly pale; sternites light yellow. Male hypopygium (Plate 2, fig. 29) with the tergite, *9t,* bearing two submedian, blackened lobes that are narrowly separated by a linear notch, the tips of the lobes obliquely truncated, provided with small black spines and numerous setæ. Outer dististyle, *od,* with a conspicuous dilation on ventral margin at near midlength, this provided with abundant setæ; beyond the dilation, the style narrows rapidly to a slender point. Inner dististyle, *id,* cultriform, bearing a blackened lobe near base. Lobes of ninth sternite with numerous conspicuous setæ.

Habitat.—Japan (Riukiu Islands).

Holotype, male, Kunjan, Okinawa, altitude 1,000 feet (*S. Sakaguchi*).

"Kunjan-gun, in the northern part of Okinawa; collections made at between 500 and 1,000 feet. The woods are dense and very humid, and along the streams were found very favorable situations for Tipulidae."—S. Sakaguchi.

Tipula okinawensis is allied to *T. yamata* Alexander (Japan) and *T. suensoni* Alexander (eastern China), agreeing in the general coloration and narrow cell 2d A of the wings. In the present species, Rs is unusually short, being less than m-cu in length, while the details of the male hypopygium, especially of the tergite and dististyles, are quite distinct. The members of this restricted group have nearly a score of powerful flattened pale setæ arranged in a comblike series along the dorsal margin of the inner dististyle.

TIPULA (VESTIPLEX) DIVISOTERGATA sp. nov. Plate 2, fig. 30.

Belongs to the *arctica* group; *himalayensis* subgroup; allied to *avicularia;* male hypopygium with the ninth tergite completely divided by pale membrane; a small foot-shaped appendage projecting from beneath each lobe of tergite.

Male.—Length, about 11 to 12 millimeters; wing, 12.5 to 14.

Frontal prolongation of head brownish yellow above, narrowly dark brown on sides; nasus long and conspicuous. Antennæ with the flagellar segments weakly bicolorous, the basal enlargement of each dark brown, the remainder more yellowish brown.

Mesonotal præscutum with a golden-yellow pollen, the three brown stripes narrowly bordered by darker brown, this especially evident on the median vitta. Pleura chiefly yellow or brownish yellow, the ventral sternopleurite a little more darkened. Halteres with the knobs dark brown, their apices conspicuously yellow. Legs with the femora brown, the tips conspicuously blackened, preceded by an obscure yellow ring of approximately equal width. Wings with the pattern about as in *himalayensis,* brown, variegated with creamy areas, especially on the basal half of wing; prearcular and costal regions more yellowish, especially the former.

Abdominal tergites yellow, narrowly trivittate with dark brown, the subterminal segments more uniformly darkened. Male hypopygium (Plate 2, fig. 30) with the tergite, 9*t,* narrowly divided medially by membrane into two halves; caudal margin of tergite with a rounded emargination, the apices of the lobes darker brown, strongly delimited; beneath each lobe on ventral face with a small bilobed structure, more or less foot-shaped, as shown. Outer dististyle, *od,* long and slender, pale throughout. Inner dististyle, *id,* with the blackened margin of the blade smooth. What seems to represent a gonapophysis is a slender, straight rod, weakly expanded at apex into a small head. Ninth sternite, 9*s,* at dorsal outer angle with a small, oval, setiferous lobule. Eighth sternite unarmed.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, July 17, 1929 (*Franck*). Paratopotype, male, July 23, 1929.

Tipula divisotergata seems to find its closest ally among the described species in *T. avicularia* Edwards (Tibet to Sikkim), differing most evidently in the structure of the hypopygium.

CYLINDROTOMINÆ

LIOGMA BREVIPECTEN sp. nov. Plate 1, fig. 4; Plate 2, fig. 31.

Antennal pectinations (male) unusually short and blunt; wings yellowish gray, the wing tip and seams at origin of Rs, along cord and outer end of cell 1st M_2 slightly darker; male hypopygium with the gonapophyses expanded at tips into large, entirely smooth, blades.

Male.—Length, about 13 millimeters; wing, 10.3.

Antennæ (Plate 2, fig. 31) with the scape dark brown, the pedicel and basal two or three flagellar segments passing into obscure yellow; outer flagellar segments brown; flagellar segments with the pectinations unusually short and blunt. Head black, sparsely pruinose.

Mesonotum and pleura black, the dorsopleural region yellow. Halteres pale. Legs with the coxæ brown basally, paler at tips; trochanters yellow; femora yellow, the distal sixth black. Wings (Plate 1, fig. 4) yellowish gray, the prearcular and costal regions more yellowish; stigma small, brown; wing tip and seams at origin of Rs, along cord and outer end of cell 1st M_2 somewhat darker; veins brown, the prearcular and costal veins clearer yellow.

Abdomen black, the outer sternites obscure yellow at base, the margins narrowly blackened. Male hypopygium with the gonapophyses dilated at tips into broadly expanded, entirely smooth blades.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Ohdai, Yamata, altitude 3,250 feet, June 5, 1930 (*S. Sakaguchi*).

The present fly is readily told by the diagnostic features listed above, notably the short antennal pectinations and smooth gonapophyses.

LIOGMA FUSCIPENNIS sp. nov. Plate 1, fig. 5; Plate 2, fig. 32.

Male.—Length, about 13 to 14 millimeters; wing, 10 to 11.5.

Generally similar to *Liogma serraticornis* Alexander (Japan) in most features, differing most evidently in the strongly darkened wings.

Serrations of the flagellum conspicuous (Plate 2, fig. 32). Dorsopleural membrane infuscated; in *serraticornis*, light ocherous. Wings (Plate 1, fig. 5) strongly infuscated, the oval stigma dark brown; cell C still more darkened. Venation: Rs shorter; r-m lost by fusion of R_{4+5} on M_{1+2}, this character constant in all specimens of the type series. In *serraticornis* the wings are conspicuously yellowish, the prearcular and costal regions, together with the stigma, more saturated.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Daisen, Tottori, altitude 3,900 feet, June 7, 1930 (*Hibi*); received through Professor Inomata. Paratopotypes, 2 males, altitude 3,900 to 4,550 feet, June 7, 1930 (*Hibi*).

The relationship of the present fly to *Liogma serraticornis* may perhaps be indicated by a trinomial.

LIMONIINÆ

LIMONIINI

LIMONIA (DICRANOMYIA) TRIFILAMENTOSA sp. nov. Plate 1, fig. 6; Plate 2, fig. 33.

Limonia (*Dicranomyia*) sp. TOKUNAGA, Mem. Coll. Agr. Kyoto Imp. Univ. 10 (1930) 73, 74, 75.

General coloration brownish yellow; antennæ with the basal flagellar segments short-oval; mesonotal præscutum with three darker brown stripes; pleura yellow, longitudinally striped with brown; fore femora with a nearly terminal dark brown ring; wings tinged with brownish yellow; Sc_2 lacking; cell M_2 open by the atrophy of m; male hypopygium with the rostral spines very unequal in length and size, the outer one long and powerful.

Male.—Length, 5.5 to 6 millimeters; wing, 5.5 to 6.

Female.—Length, about 6 to 7 millimeters; wing, 5.5 to 6.

Described from alcoholic specimens.

Rostrum brownish yellow; palpi short, dark brown. Antennæ brown; basal flagellar segments short-oval, the outer segments more elongate-oval; setæ of segments of normal length and size. Head brownish yellow, the center of the vertex darker.

Mesonotal præscutum brownish yellow, with three darker brown stripes, the median stripe narrowly divided by a capillary pale line, most distinct behind; scutal lobes darkened; median region of scutum, and sometimes of scutellum and postnotal mediotergite, restrictedly pale, in other specimens more uniformly darkened. Pleura yellow, striped longitudinally with brown, the dorsal sternopleurite pale. Halteres pale. Legs with the coxæ and trochanters pale; fore femora obscure yellow, with a broad, nearly terminal, dark brown ring; other femora not or only slightly darkened apically; tibiæ and tarsi brownish yellow, the latter only slightly darkened outwardly; claws with five or six teeth, only the outermost of large size. Wings (Plate 1, fig. 6) with a strong brownish yellow tinge, without markings; veins brown. Venation: Sc_1 ending opposite the origin of Rs, Sc_2 lacking; a supernumerary crossvein in cell Sc at near midlength of R; cell M_2 open by atrophy of m, closed only in aberrant individuals; m-cu at or, more usually, a short distance before the fork of M.

Abdomen brown, the sternites somewhat paler. Male hypopygium (Plate 2, fig. 33) with the ninth tergite, *9t*, transverse, the caudal margin convexly rounded, the median region restrictedly transverse or even feebly concave. Basistyle, *b*, relatively small. Ventral dististyle, *vd*, fleshy, the rostral prolongation weakly chitinized, with two very unequal and widely separated spines. Dorsal dististyle a curved sickle, widest just beyond midlength. Gonapophyses, *g*, with the mesal-apical lobe elongate, a little expanded at tip and with the margin microscopically serrulate.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Seto, Wakayama-ken, April 15, 1928 (*M. Tokunaga*); marine. Allotopotype, female. Paratopotypes, of both sexes.

In 1928, Dr. Masaaki Tokunaga, while working at the Seto Marine Biological Laboratory, discovered no fewer than three species of marine crane flies, all of which proved to be undescribed. Through the kindness of the collector, two of these species are defined in this report, as *Limonia* (*Dicranomyia*) *trifilamentosa* sp. nov. and *Limonia* (*Idioglochina*) *tokunagai* sp. nov. The third species, *Limonia* (*Dicranomyia*) *monostromia* Tokunaga, has been described in all stages in a beautiful monographic study by the author of the species.[3] The pupa of the present species is most remarkable in the genus *Limonia* in having three-branched breathing horns, whence the specific name, *trifilamentosa.* The discovery of this fly serves to bridge the gap existing between the crane flies of the subtribe Antocharia, having many-branched pronotal breathing horns, and the remaining members of the family, in which this structure is simple. The only other Japanese *Dicranomyia* having cell M_2 open by the atrophy of m is the very different *L.* (*D.*) *immodestoides* (Alexander) with an entirely distinct male hypopygium.

LIMONIA (IDIOGLOCHINA) TOKUNAGAI sp. nov. Plate 1, fig. 7; Plate 2, fig. 34.

? *Gonomyia*, sp. TOKUNAGA, Mem. Coll. Agr. Kyoto Imp. Univ. 10 (1930) 73, 74, 75.

General coloration dark brown to brownish black, probably pruinose in dry specimens; flagellar segments strongly produced; a supernumerary crossvein in cell Sc; male hypopygium with the ventral dististyle a subglobular structure, the rostral prolongation very short and stout, provided with two unequal spines.

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[3] Mem. Coll. Agr. Kyoto Imp. Univ. 10 (1930) 1–127, 17 pls.

Male.—Length, about 5.5 to 7.5 millimeters; wing, 6.2 to 9.

Female.—Length, about 7.5 to 10 millimeters; wing, 6.5 to 10.5.

Described from alcoholic specimens.

Rostrum and palpi brown. Antennæ brownish black throughout; intermediate ten flagellar segments very strongly produced. Head dark brown.

Mesothorax chiefly dark brown, probably pruinose in fresh specimens; scutellum brightened, especially on posterior half. Halteres pale, especially the knobs. Wings (Plate 1, fig. 7) with a strong dusky suffusion, the stigma and vague seams along the cord somewhat darker; veins dark brown. Venation: A supernumerary crossvein in cell Sc at near midlength of vein R; veins of radial field not greatly distorted; cell 1st M_2 closed, as long as or longer than vein M_{1+2} beyond it; m-cu at or before fork of M.

Abdominal tergites black, the sternites somewhat brighter, their caudal margins narrowly darkened; hypopygium black. Male hypopygium (Plate 2, fig. 34) with the tergite, *9t,* extensive, the caudal margin with a deep and narrow median incision. Basistyle, *b,* elongate, the ventromesal lobe low. Ventral dististyle, *vd,* a subglobular, fleshy structure, the dorsal face deeply incised for the reception of the dorsal dististyle; rostral prolongation very short and obtuse, with two spines, the outer one larger and more powerful than the inner. Gonapophyses narrow, the apical lobe very elongate, obtuse at tip, set with numerous depressed areas.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Seto, Wakayama-ken, April 15, 1928 (*M. Tokunaga*). Allotopotype, female. Paratopotypes, of both sexes; additional paratopotypes of the smaller summer form, August 15, 1928 (*M. Tokunaga*).

Limonia (*Idioglochina*) *tokunagai* is named after the collector, Dr. Masaaki Tokunaga, student of the marine Diptera of Japan. It is one of three marine crane flies belonging to the genus *Limonia* taken by the collector on the Kii Peninsula in 1928.[4] The present species is very different from the only other described regional *Idioglochina, L.* (*I.*) *kotoshoensis* (Alexander), in the nature of serration of the antennal flagellum. It seems highly probable that the larval stage of all of the various species of this subgenus in the Australasian, Oriental, and eastern Palæarctic Regions will be found to occur in a marine habitat. The various members of the group have possibly been derived from some ancestral marine *Dicranomyia* of the general type of *L.* (*D.*) *signipennis* (Coquillett) or *L.* (*D.*) *monostromia* Tokunaga. With the recent discovery[5] by Dr. L. G. Saunders of the marine habitat of *Limonia* (*Geranomyia*) *unicolor* (Haliday), a third subgenus of *Limonia* is thus shown to have marine representatives. The seasonal dimorphism in the present species as briefly noted by Tokunaga[6] is very curious, both sexes of the vernal form being fully one-half larger than the corresponding summer form.

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[4] Op. cit.

PROANTOCHA QUADRIVITTATA sp. nov. Plate 1, fig. 8.

Male.—Length, about 9 millimeters; wing, 9.

Described from an alcoholic specimen.

Most closely related to *P. spinifer* (Alexander) and *P. serricauda* (Alexander) in the general nature of the vestiture of the legs, differing especially in the thoracic pattern.

Mesonotal præscutum with four distinct brown stripes, the intermediate pair closely approximated for most of their length but well-separated behind; lateral stripes not reaching the suture; scutal lobes each with two dark areas, the more-posterior one larger; postnotal mediotergite with two large, brown, confluent, circular areas on posterior margin. Pleura pale, distinctly marked with brown on the anepisternum and ventral sternopleurite. Fore and middle legs with long abundant delicate setæ; of posterior legs shorter and more reduced, but not spinous; posterior tibiæ with long setæ from enlarged bases, where the setæ are broken, leaving spinous points. Wings as illustrated (Plate 1, fig. 8).

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Saga, Kyoto Prefecture, altitude 490 feet, August 10, 1929 (*Tokunaga*).

Proantocha quadrivittata is intermediate in size between *P. spinifer* and *P. serricauda*, differing from both in the nature of the thoracic pattern. *Proantocha ūyei* Alexander is a very different species, with the vestiture of all legs greatly reduced to spines and short spinous setæ.

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[5] Ent. Mo. Mag. 66 (1930) 185–187, figs.

[6] Op. cit. 73.

ANTOCHA SAGANA sp. nov. Plate 1, fig. 9; Plate 2, fig. 35.

General coloration pale, the mesonotal præscutum with a dark brown median stripe; ventral sternopleurite darkened; wings grayish, unmarked; male hypopygium with the ninth tergite evenly covered with microscopic setulæ, its caudal margin gently trilobed; a small setiferous lobule on mesal face of basistyle; both diststyles of nearly equal size and length, weakly expanded into a blade at outer end.

Male.—Length, about 4.2 millimeters; wing, 4.5.

Described from an alcoholic specimen.

Rostrum pale yellow; palpi brown. Antennæ with the space pale, the pedicel and flagellum dark brown; flagellar segments oval, the outer segments becoming more elongate. Head dark brown, the front pale yellow.

Pronotum and mesonotum yellow, with a dark brown median stripe that narrows behind on the præscutum, becoming obsolete some distance before the suture; lateral præscutal stripes lacking; cephalic portions of scutal lobes darkened; posterior half of postnotal mediotergite darkened. Pleura pale, the ventral sternopleurite extensively infuscated. Halteres pale, the outer portion of the stem slightly more infuscated. Legs with the coxæ pale, the fore coxæ more infuscated; trochanters pale; remainder of legs light brown. Wings (Plate 1, fig. 9) with a grayish tinge, the base more whitish; stigma lacking; veins very pale. Macrotrichia on distal two-thirds of last section of R_{4+5} and of M_{1+2}. Venation: Sc relatively short, Sc_1 ending about opposite three-fourths the long Rs; m-cu about one-third its length before the fork of M.

Abdomen pale, the tergal incisures restrictedly darkened. Male hypopygium (Plate 2, fig. 35) with the tergite, 9*t*, extensive, its caudal margin gently trilobed, the surface entirely covered by small delicate setulæ. Basistyle, *b*, with a small setiferous lobule on mesal face at base. Both diststyles relatively elongate, of generally equal size and shape, being slightly arcuate, the distal ends weakly expanded into a blade; outer style, *od*, glabrous, the inner style, *id*, with long, coarse, chiefly marginal setæ.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Saga, Kyoto Prefecture, altitude 490 feet, April 15, 1928 (*Tokunaga*).

Antocha sagana is readily told from all other regional species of the genus by the structure of the male hypopygium, especially of the diststyles.

DICRANOPTYCHA MACHIDANA sp. nov. Plate 1, fig. 10; Plate 3, fig. 36.

General coloration dark brown, including the abdomen; halteres yellow; legs yellow, the tips of femora narrowly but abruptly blackened; extreme base and tip of tibia more narrowly blackened; wings brownish yellow, the veins dark brown, those in the costal and prearcular areas more yellowish; male hypopygium with the lateral lobes of the tergite appearing as pale spatulate blades; inner dististyle terminating in a yellow apical point.

Male.—Length, about 8.5 millimeters; wing, 10.5.

Rostrum and palpi dark brown. Antennæ with the scape dark brown above, paler beneath; pedicel blackened, paler apically; flagellum broken. Head dark brown, crushed in the type.

Thorax chiefly dark brown, badly crushed in the type, the pleural sclerites surrounding the wing root paler. Halteres yellow. Legs with the coxæ and trochanters yellow, the fore coxæ darker; femora yellow, the tips narrowly but conspicuously blackened; tibiæ yellow, the extreme base very narrowly, the tip a trifle more broadly blackened; basitarsi yellow, the tips and remainder of tarsi brownish black. Wings (Plate 1, fig. 10) brownish yellow, the costal and prearcular regions clearer yellow; veins dark brown, C, Sc, R, and the prearcular veins more yellowish. Venation: Rs long, fully three times the basal section of R_{4+5}.

Abdomen brownish black, the hypopygium a little paler. Male hypopygium (Plate 3, fig. 36) with the lateral lobes of tergite, *9t*, appearing as pale, spatulate blades, their apices evenly rounded. Outer dististyle, *od*, slender, the distal third blackened and set with appressed to suberect spines. Inner dististyle, *id*, elongate, narrowed outwardly and terminating in a chitinized yellow apical point.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Hakutai, Chichibu, August 25, 1930 (*J. Machida*).

I take great pleasure in naming this distinct fly after the collector, my friend Dr. Jiro Machida, to whom I am very greatly indebted for many interesting Japanese Tipulidæ. The species is most similar in its general features to *Dicranoptycha geniculata* Alexander (Formosa), the pattern of the legs being very similar in the two flies. It differs very conspicuously in the wing markings, venation, and structure of the male hypopygium. The present species is very different from the other members of the genus known from the major islands of Japan.

HELIUS (HELIUS) PLUTO sp. nov. Plate 1, fig. 11; Plate 3, fig. 37.

Allied to *H.* (*H.*) *tenuirostris;* general coloration of thorax brownish black; legs brownish black; wings with a faint brown tinge, the base and costal region light yellow; male hypopygium with the lateral lobe of tergite terminating in a slender acute spine; apex of inner dististyle long and slender.

Male.—Length, excluding rostrum, about 8 millimeters; wing, 8; rostrum, 2.7.

Female.—Length, excluding rostrum, about 9 millimeters; wing, 8; rostrum, 2.8.

Rostrum black, elongate, as shown by the measurements, being approximately as long as the combined head and thorax; palpi black. Antennæ black throughout. Head dark gray; anterior vertex relatively narrow, approximately as wide as the diameter of the base of rostrum, provided with numerous erect black setæ; ommatidia fine.

Pronotum and cervical sclerites dark brown, the former paling to obscure yellow on sides. Mesonotum chiefly brownish black, the humeral region of præscutum vaguely brightened. Pleura chiefly brownish black, the dorsal pteropleurite paler. Halteres light brown, the base of stem paler. Legs with the fore coxæ dark brown, the remaining coxæ brownish yellow; trochanters light yellow; remainder of legs brownish black, the femoral bases obscure yellow, most extensive on posterior legs. Wings (Plate 1, fig. 11) with a faint brownish tinge, the base and costal region light yellow; stigma oval, darker brown; a dusky seam adjoining vein Cu_1; veins dark brown. Venation: Sc_1 ending shortly before the fork of Rs, Sc_2 at the extreme tip and more heavily sclerotized; branches of Rs gently diverging; m-cu close to fork of M.

Abdominal tergites feebly dimidiate, light brown basally, the caudal half black, the amount of the latter increasing on the outer segments. In female the tergites are more uniformly darkened. Male hypopygium (Plate 3, fig. 37) with the lateral lobes of the tergite, *9t,* terminating in a slender acute spine. Basistyle, *b,* with the mesal face densely set with setæ. Outer dististyle, *od,* a straight blackened rod, the apex very weakly bispinous. Apex of inner dististyle, *id,* very long and narrow.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 3,000 feet, July 25, 1930 (*Franck*). Allotopotype, female, July 23, 1930.

Helius (*Helius*) *pluto* is most nearly allied to *H.* (*H.*) *rufithorax* Alexander (Formosa) and *H.* (*H.*) *tenuirostris* Alexander

(Japan), differing from the former in the coloration of the thorax and from the latter in the larger size and general coloration. The distinctive features of the male hypopygium of the present fly lie in the shape of the lateral lobes of the tergite and the long, slender tip of the inner dististyle. It should be noted that the abdomen of the male of *tenuirostris* has the individual segments dimidiate, yellow on the basal half, the apices abruptly blackened. This character was wrongly described by the writer in the original definition of this species.

HEXATOMINI

POLYMERA PARVICORNIS sp. nov. Plate 1, fig. 12; Plate 3, fig. 38.

General coloration pale brown; antennæ short; wings tinged with brown; no stigmal area; cell M_1 present; male hypopygium with the outer dististyle a simple rod, the tip obtuse, with an acute subapical spine.

Male.—Length, about 4.5 millimeters; wing, 4.6.

Described from an alcoholic specimen.

Rostrum short, pale yellow; palpi relatively long, especially the two, slender, terminal segments, the whole about one-third longer than the head and some two-thirds as long as the antenna. Antennæ with the scape and pedicel yellow, the flagellum dark brown; antennæ (male) short and unmodified, about as long as the thorax alone; antennæ apparently only 15-segmented, the segments subcylindrical; terminal segment elongate, nearly as long as the preceding two segments combined and apparently formed by the fusion of segments. Head brown, the front and broad orbits yellowish.

Pronotum brown. Mesonotum brownish yellow, the præscutum with a double yellow area on disk, narrowly margined with delicate brown lines, the dividing mark on the median area of the sclerite; extreme cephalic-median portion of præscutum darkened; mesal edges of scutal lobes similarly dark-margined; a narrow median yellow vitta extending from the suture to mid-length of the postnotal mediotergite, more interrupted on the scutellum; pseudosutural foveæ very small, pale. Pleura yellow, the dorsal sclerites more darkened. Halteres pale, the bases of the knobs a little darker. Legs with the coxæ and trochanters yellow; remainder of legs pale brown; segments with relatively long, conspicuous setæ; claws small. Wings (Plate 1, fig. 12) tinged with brown; no stigmal area or other markings; veins pale brown, with long conspicuous black verticils on almost all longitudinal veins, lacking on basal half of first section of Cu_1

and 2d A. Venation: Sc_1 ending shortly before fork of Rs, Sc_2 a short distance from its tip; R_{2+3+4} longer than R_{2+3}; R_2 faint; R_{1+2} a little longer than R_{2+3+4}; cell M_1 present; m-cu close to fork of M; anterior arculus present.

Abdomen brown, the sternites paler. Male hypopygium (Plate 3, fig. 38) with the outer dististyle, *od*, a simple, nearly straight rod, the apex bluntly obtuse, with a small subapical appressed spine.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Kibune, Kyoto Prefecture, altitude 750 feet, at light, June 1, 1930 (*Tokunaga*).

The generic reference of this curious fly must be considered as being somewhat provisional, since the species differs so conspicuously from all hitherto-described members of the genus in the short male antennæ. I at first considered the fly to belong to *Troglophila* Brunetti, where it would be equally isolated by the brevity and structure of the antennæ. The venation and trichiation, together with the basic plan of structure of the male hypopygium, are so much as in *Polymera* that I am venturing to refer the species to this essentially Neotropical genus of Tipulidæ. It would appear that *Troglophila* Brunetti and *Polymera* Wiedemann are more closely allied than was hitherto considered. The ecological conditions at Kibune have been described and figured by Iwata, in an entomological survey of the upper Kamogawa River, with special reference to trichopterous larvæ and pupæ.[7]

LIMNOPHILA (ELÆOPHILA) SERRULATA sp. nov. Plate 1, fig. 13; Plate 3, fig. 39.

Size small (wing, male, 5 millimeters); legs yellow, the femora with a very slightly darker brown ring immediately before tips; wings (male) suddenly widest opposite end of vein 2d A; whitish, with an abundant dotted and spotted brown pattern; male hypopygium with the apex of the outer dististyle microscopically serrulate.

Male.—Length, about 4.2 millimeters; wing, 5.

Rostrum and palpi black. Antennæ with the scape and pedicel black; basal segments of flagellum pale brown, the outer segments somewhat darker; basal flagellar segments somewhat swollen on ventral face. Head blackish, the anterior vertex and narrow orbits more grayish.

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[7] Bull. Biogeograph. Soc. Japan No. 1, 2 (1930) 1–20, 5 pls.

Mesonotum yellowish gray, conspicuously variegated with dark brown stripes and dashes, including two elongate intermediate stripes that are obsolete in front and interrupted just before suture; lateral stripes bending mesad and becoming confluent at anterior ends with the intermediate stripes; extreme lateral margins of præscutum, behind the pseudosutural foveæ, dark brown; a series of three or four brown punctigerous spots on posterior interspaces; pseudosutural foveæ black; posterior sclerites of mesonotum chiefly blackened. Pleura black, sparsely interspersed with more-grayish areas. Halteres yellow, the knobs brownish black. Legs with the coxæ and trochanters blackish, the latter slightly brightened at bases; remainder of legs yellow, the femora with a slightly darker brown subterminal ring. Wings (Plate 1, fig. 13) with the ground color whitish, the prearcular region light yellow; an abundant dotted and spotted brown pattern, including about six major costal areas, the second at level of origin of Rs entirely crossing the wing as a narrow fascia; third area at end of Sc, fourth at tip of R_{1+2}, the two latter converging behind to form the largest area on disk, lying over the anterior cord; fifth and sixth costal areas at ends of veins R_3 and R_4, respectively; wing apex as far caudad as cubital field, narrowly bordered by brown; interspaces with numerous small brown dots, mostly contiguous to the veins but with some in centers of cells; veins pale, darker in the infuscated areas. Wing (male) abruptly widest opposite end of vein 2d A. Costal fringe of moderate length only. Venation: Supernumerary crossvein in cell M lying immediately distad of level of origin of Rs.

Abdominal tergites black, the sternites paler medially. Male hypopygium (Plate 3, fig. 39) with the basistyle, *b*, produced mesally into an obtuse lobe. Outer dististyle, *od*, with the outer spine relatively blunt, placed at beyond midlength of style; apex of style microscopically serrulate. Inner dististyle relatively narrow.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 4,000 feet, July 28, 1930 (*Franck*).

Of the regional species in eastern Asia, *Limnophila* (*Elæophila*) *serrulata* most resembles *L.* (*E.*) *dietziana* Alexander (Japan) in its small size and abundantly spotted wings, differing conspicuously in the lack of black femoral tips and the serrulate outer dististyle of the male hypopygium. In the latter character, the present fly likewise differs from the larger *L.* (*E.*) *suensoni* Alexander (eastern China). There seems to be no possibility of our further refusing to use the subgeneric term *Elæophila* Rondani, in place of the more familiar and generally used *Ephelia* Schiner.

LIMNOPHILA IMANISHII sp. nov. Plate 3, fig. 40.

Subapterous, at least in the female sex; antennæ 13-segmented the flagellar segments short-oval; terminal segment elongate, evidently resulting from the fusion of two segments.

Female.—Length, about 8 millimeters; wing, 1.3.

Rostrum brown; palpi with the terminal segment considerably longer than the third. Antennæ (Plate 3, fig. 40) 13-segmented, brown throughout; pedicel not conspicuously elongate, about one-half the length of the scape; flagellar segments short-oval to subglobular; outer segments becoming more elongate, the penultimate with an apical ring of verticils in addition to the basal ring; terminal segment elongate, equal to the preceding two taken together, with an incomplete suture, indicating a fusion of segments. Head brown.

Mesonotum relatively small, brown. Halteres pale, small, about one-half the length of the wings, the club linear. Legs with the middle and hind coxæ elongate, dark brown; trochanters brown; legs relatively short and stout, brownish yellow; tibial spurs elongate, setiferous; tarsal claws smooth. Wings greatly reduced, stenopterous, uniformly yellowish brown; no clearly defined venation except beyond the cord where indicated by macrotrichia; cell M_1 present. Macrotrichia on C and R for almost their entire length, on other veins only beyond the level of the cord, on R_4, M_1, M_2, M_3, and M_4.

Abdomen dark brown, the lateral line somewhat darker. Ovipositor with the tergal valves elongate, slender, gently upcurved; sternal valves compressed.

Habitat.—Japan (Honshiu).

Holotype, alcoholic female, Bogaya, Toyama, Japanese Alps, altitude 3,900 feet, on snow (*Imanishi*).

Limnophila imanishii is named in honor of the collector, Mr. K. Imanishi, who has taken many rare Tipulidæ in the Japanese mountains. The species cannot be associated with any of those previously described. I place the fly in *Limnophila* in the broad definition of the genus only. Nearly apterous females of hexatomine and pediciine Tipulidæ are very difficult to place accurately as to genus, but the reference of the present fly to the Hexatomini seems justified by the glabrous eyes.

ERIOCERA NIGROTROCHANTERATA sp. nov. Plate 1, fig. 14.

Male.—Length, about 13 millimeters; wing, 16 by 5.

Belongs to the *spinosa* group; closely related to *E. issikii* Alexander (Honshiu) in the short antennæ of the male sex.

Rostrum and palpi black. Antennæ black throughout, 7-segmented; terminal segment small; first flagellar segment longer and slenderer than in *issikii*, being approximately one-third longer than the second palpal segment; in *issikii* the second palpal segment is subequal to or even a little longer than the first flagellar segment. Mesonotal præscutum with four dark stripes, the intermediate pair narrow; in *issikii*, with three such stripes, the broad median stripe being entire; scutellum black. Halteres black, only the base of stem pale. Hind legs with the black femoral tips narrow, including about the distal fourth; in *issikii* broad, including the distal half or slightly more. Wings (Plate 1, fig. 14) somewhat shorter and broader; veins of radial and medial fields with broad, conspicuous, brown seams.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Ohdai, Yamato, altitude 2,600 feet, June 5, 1930 (*Sakaguchi*).

ERIOCERA KELLOGGI sp. nov. Plate 1, fig. 15.

General coloration black, the thoracic stripes and bases of abdominal tergites more plumbeous, glabrous; femora and halteres black; wings brown, the base paler than the apical third, with a very vague, more yellowish crossband before the cord; macrotrichia of costa much reduced in size and number.

Male.—Length, about 16 millimeters; wing, 15.5.

Rostrum and palpi black. Antennæ 7-segmented; scape and pedicel dark brown; flagellum yellowish brown, the outer segments again darkened. Head black, the vertical tubercle relatively low.

Mesonotal præscutum grayish brown, with four subnitidous, plumbeous black stripes that are narrowly separated by lines of opaque black; posterior sclerites of mesonotum dull black. Pleura black. Halteres black. Legs with the coxæ and trochanters black; femora brownish black; tibiæ brown, the tips narrowly darkened; tarsi dark brown. Wings (Plate 1, fig. 15) very vaguely cross-banded, the basal two-thirds obscure brownish yellow, the apical third infuscated, preceded by a scarcely defined clearer yellow crossband before the cord, most extensive in the radial and medial fields, more or less narrowed to a point posteriorly at m-cu; costal region more intense orange-yellow; veins yellow, somewhat darker in the infumed apical portion. Macrotrichia of veins very small and reduced, very evidently so on costa between h and the level of R_2, the trichia becoming more abundant on costa beyond the latter point to the wing tip. Venation: Tip of Sc_1 atrophied about opposite R_2; cell M_1 present; m-cu at near midlength of cell 1st M_2.

Abdominal tergites polished leaden blue-black, the caudal margins opaque black, the latter including about the apical third of the intermediate segments; sternites and hypopygium black.

Habitat.—China (Fukien).

Holotype, male, Foochow (*Kellogg*).

I take great pleasure in naming this species in honor of the collector, Prof. Claude R. Kellogg, of the Massachusetts State College. By Edwards's key to the Old World species of *Eriocera*[8] the present fly runs to couplet 71, disagreeing in the combination of leaden basal crossbands on the abdominal tergites, in conjunction with the presence of cell M_1 of the wings. It is closely allied to *E. muiri* Alexander, of Macao,[9] which differs in the clearly defined yellow crossband of the wing and the more-abundant macrotrichia of the veins of the radial and medial fields. The great reduction in number and size of the macrotrichia of the costa in *E. mesopyrrha* (Wiedemann), *E. prælata* Alexander, *E. muiri* Alexander, the present species, and probably still others in the Oriental and Eastern Palæarctic faunal regions is noteworthy.

ERIOCERA ARROGANS Alexander.

Eriocera arrogans ALEXANDER, Proc. U. S. Nat. Mus. 72, art. 2 (1927) 5–6.

Described from a unique female specimen taken at Mount Omei, Szechwan, China, by Rev. David C. Graham. Three additional specimens were taken at Kwanhsien, Szechwan, altitude 3,000 feet, July 18 to 24, 1930; altitude 4,000 feet, August 12, 1930 (*Franck*).

The males are much smaller than the females (length, 8 to 8.5 millimeters; wing, 9.2 to 9.8) and have the wings almost uniformly blackened, without the conspicuous pale centers to the cells found in the female sex. By Edwards's key to the

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[8] Ann. & Mag. Nat. Hist. IX 8 (1921) 70–78.

[9] Proc. Hawaiian Ent. Soc. 5 (1923) 255.

Old World species of *Eriocera*,[10] the fly runs to *E. unicolor* de Meijere,[11] differing in the small size and details of coloration. The specimens from Formosa referred to *unicolor* by Edwards[12] were later described as a new species, *E. lygropis* Alexander.[13]

ERIOCERA CÆSAREA Alexander.

Eriocera cæsarea ALEXANDER, Philip. Journ. Sci. 44 (1931) 358–359.

The fly was described from a unique male specimen, taken at Kwanhsien, Szechwan, China, by Rev. David C. Graham. An additional male from the type locality (altitude 2,800 feet, July 28, 1930, *Franck*) agrees closely with the type, differing in a few details only. Wings with indications of a very broad, scarcely evident, yellowish brightening before the cord. Venation: Cell 1st M_2 slightly more elongate, with m-cu at midlength of its lower face.

ERIOCERA KAMIYAI sp. nov. Plate 1, fig. 16.

General coloration velvety black, including the head, thorax, and abdomen; mesonotal præscutum with four polished black stripes; halteres entirely black; legs black, the femora chiefly yellow, the tips blackened; wings with the ground color cream-yellow, very heavily patterned with brown, including cells C and Sc and broad seams at origin of Rs, along cord and outer end of cell 1st M_2; vein R_{2+3+4} short.

Male.—Length, about 12 millimeters; wing, 11.3.

Rostrum and palpi black. Antennæ black throughout, the terminal segments broken. Head velvety black; vertical tubercle conspicuous.

Mesonotal præscutum velvety black, with four polished black stripes that are little evident against the ground color; remainder of mesonotum and pleura velvety black. Halteres short, black throughout. Legs with the coxæ and trochanters black; femora obscure yellow, the tips blackened, narrowest on the posterior legs; tibiæ and tarsi black. Wings (Plate 1, fig. 16) with the ground color cream-yellow but almost concealed by an extensive dark brown pattern, chiefly evident in the cells before and beyond the cord; cells C and Sc uniformly darkened; very extensive dark clouds at origin of Rs, along cord, at stigma, and outer end of cell 1st M_2; wing apex margined with dusky;

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[10] Loc. cit.

[11] Fauna Simalurensis—Diptera, Tijd. voor Ent. 58 (1915) 12–13.

[12] Ann. & Mag. Nat. Hist. VIII 18 (1916) 253.

[13] Ann. Ent. Soc. Am. 13 (1920) 259–260.

anal cells more uniformly grayish brown; veins black. Venation: R_{2+3+4} short, a little more than one-half the basal section of R_5; R_2 less than R_{1+2}, placed shortly before midlength of the anterior branch of Rs; cell M_1 lacking; m-cu just beyond one-third the length of the long cell 1st M_2; distal section of Cu_1 short.

Abdomen velvety black, including the hypopygium.

Habitat.—Japan (Honshiu).

Holotype, male, Kamikochi, Shinano, Japanese Alps, July 29, 1930 (*Kamiya*); through Dr. Jiro Machida.

Eriocera kamiyai is named in honor of the collector, Mr. K. Kamiya. The species is most nearly allied to *E. fulvibasis* Alexander, *E. longifurca* Alexander, and *E. subrectangularis* Alexander, all of Japan, differing in the velvety black coloration of the body and halteres, and the unusually heavy pattern of the wings, cells C and Sc being uniformly darkened.

ATARBA (ATARBODES) BIPUNCTULATA sp. nov. Plate 1, fig. 17; Plate 3, fig. 41.

General coloration pale yellow, each side of pleura with two dark brown spots, placed on the pteropleurite and the pleurotergite; halteres and legs yellow; wings with a strong yellow tinge; Sc relatively long, Sc_1 ending opposite or beyond midlength of Rs; male hypopygium with the outer dististyle bearing spines on the distal fifth or less; gonapophyses appearing as short, macelike structures.

Male.—Length, about 4.5 millimeters; wing, 5.

Rostrum whitish yellow; palpi with the basal segment yellow, the remainder black. Antennæ with the scape and pedicel brown, the flagellum brownish black; antennæ (male) short, the segments with long conspicuous verticils that much exceed the segments. Head light yellow.

Mesonotum pale yellow, the præscutum a trifle more brownish yellow in front but otherwise immaculate; scutellum testaceous. Pleura pale yellow, with a conspicuous brownish black spot on pteropleurite, and another, slightly more elongate, paler brown area on the pleurotergite. Halteres pale yellow. Legs with the coxæ and trochanters yellow; remainder of legs yellow, without infuscation on femora or tibiæ; outer tarsal segments a little darker. Wings (Plate 1, fig. 17) with a strong yellow tinge, the veins deeper yellow, some of them very pale and indistinct; veins beyond cord with conspicuous macrotrichia. Venation: Sc relatively long, Sc_1 ending about opposite or just beyond midlength of Rs.

Abdomen yellow, the subterminal segments brown. Male hypopygium (Plate 3, fig. 41) with the basistyle, *b,* unarmed with a lobe on mesal face at apex. Outer dististyle, *od,* with the apex blackened and here provided with many subappressed spines, the latter not including more than the distal fifth of style; inner dististyle longer than the outer, more expanded at near midlength. Ædeagus long. Gonapophyses, *g,* appearing as short, powerful, macelike structures, the apex of each set with many short spines.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 3,000 feet, July 19, 1930 (*Franck*).

By my key to the species of *Atarba* of the eastern Palæarctic Region[14] the present species runs to *A. leptoxantha* Alexander (Formosa) and *A. issikiana* Alexander (Formosa). It differs very conspicuously in the structure of the male hypopygium, notably the toothing of the outer dististyle and the peculiar macelike structure of the gonapophyses.

ERIOPTERINI

CHIONEA NIPPONICA sp. nov. Plate 3, fig. 42.

Allied to *C. araneoides;* male hypopygium with the dististyle terminating in spinous setæ; gonapophyses appearing as pale flattened plates.

Male.—Length, about 5.5 millimeters.

Female.—Length, about 6 millimeters.

Closely allied to *C. araneoides* Dalman (Plate 3, fig. 43), differing especially in the structure of the male hypopygium.

Antennæ, male, 9- to 10-segmented; female, 10-segmented. Male hypopygium (Plate 3, fig. 42) with the basistyle, *b,* stout, the mesal face at proximal end with an oval area set with long erect setæ. Outer lobe of dististyle a small stout blackened structure, weakly bidentate; main arm of style long and slender, at base on inner margin with a blunt tooth; apex of style, *d,* with several spinous setæ, outer face of style with the setæ greatly reduced in number. Gonapophyses, *g,* appearing as pale flattened plates that converge toward the ædeagus. The paratype has the group of setæ on mesal face of basistyle less restricted in area.

Chionea araneoides (Plate 3, fig. 43) lacks a delimited setiferous area on mesal face of basistyle, *b.* Outer lobe of dististyle more acutely produced into a blackened tooth; main arm with only a slight convexity at base, this with conspicuous setæ; surface of style, *d*, with long conspicuous setæ, those at apex not stout and spinous. Gonapophyses, *g*, appearing as blackened toothlike structures.

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[14] Philip. Journ. Sci. 42 (1930) 526.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Tsurugi, Toyama, Japanese Alps, altitude 8,775 feet, on snow, October 20, 1928 (*Imanishi*). Allotopotype, female, with the type; Tokunaga No. 10. Paratopotype, female, October 16, 1928; Tokunaga No. 14. Paratype, male, Seki, Niigata, altitude 2,925 feet, January 11, 1923 (*ex Tokunaga*).

Chionea nipponica is readily distinguished from the allied *C. araneoides* Dalman (Europe) by the structure of the male hypopygium. This is very probably the species recorded by Matsumura[15] as *Chionea araneoides*, taken indoors during November at Sapporo, Hokkaido. The present records are the most southerly for any member of the genus *Chionea* in eastern Asia.

GONOMYIA (GONOMYIA) SUBCOGNATELLA sp. nov. Plate 1, fig. 18; Plate 3, fig. 44.

Belongs to the *cognatella* group; rostrum and palpi black; antennæ with the two basal segments yellow, the remainder black; thoracic pleura dark brown, with a broad, yellowish white, longitudinal stripe; wings with a strong brownish yellow tinge, the stigma slightly darker; R_{2+3+4} arcuated; abdominal segments dimidiate, dark brown, ringed caudally with yellow; male hypopygium with the outer dististyle a slender, setiferous rod; inner dististyle with the inner arm terminating in a very long, black spine.

Male.—Length, about 3.5 millimeters; wing, 4.2.

Female.—Length, about 4.5 millimeters; wing, 4.6.

Rostrum and palpi brownish black. Antennæ with the scape and pedicel light yellow; flagellum black; flagellar segments long-oval, clothed with a dense white pubescence. Head light yellow, the center of vertex infuscated.

Pronotum and anterior lateral pretergites light yellow. Mesonotal præscutum brownish gray; pseudosutural foveæ dark reddish; scutellum yellow, more infuscated in female. Pleura dark brown, with a broad yellowish white longitudinal stripe extending from and including the fore coxæ, occupying the dorsal sternopleurite, ventral pteropleurite, and most of the meral region. Halteres pale, the knobs weakly darkened. Legs with the fore coxæ very pale yellow, the remaining coxæ and all trochanters brownish yellow; remainder of legs pale brown, the femoral bases paler. Wings (Plate 1, fig. 18) with a strong brownish yellow tinge, the prearcular and costal regions clear light yellow; stigma a little darker than the ground color; a scarcely indicated darkened seam along cord; veins light brown, brighter in the yellow areas. Venation: Sc_1 ending opposite or just beyond origin of Rs, Sc_2 at its extreme tip, not apparent in the type female; R_{2+3+4} rather strongly arcuated, less so in female; cell 1st M_2 open by atrophy of basal section of M_3; m-cu close to fork of M.

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[15] Konchu Bunruigaku 2 (1915) 63, pl. 2, fig. 15.

Abdominal tergites dark brown, conspicuously ringed caudally with yellow; sternites paler brown, the caudal margins yellow. Male hypopygium (Plate 3, fig. 44) with the outer dististyle, *od,* slender, simple, with numerous setæ, especially along outer face. Inner dististyle, *id,* with the inner arm, *ia,* slender, terminating in a very long, slender, black spine.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 3,000 feet, July 18, 1930 (*Franck*). Allotype, female, Chengtu, altitude 1,700 feet, May 21, 1930 (*Franck*).

The possibility exists that the female allotype may not be conspecific with the type male. *Gonomyia* (*Gonomyia*) *subcognatella* differs from *G.* (*G.*) *aperta* Brunetti (British India) in the coloration of the pleura and abdomen and in the details of venation. These are the only two members of this characteristic group of the genus known to me in Asia. Of the numerous Nearctic species of the group, the present fly has an outer dististyle that is most like that of *G.* (*G.*) *kansensis* Alexander, while the simple inner arm of the inner dististyle is somewhat like that found in *G.* (*G.*) *florens* Alexander. The unusually long spine of this arm of the dististyle is distinctive of the present species.

ORMOSIA TOKUNAGAI sp. nov. Plate 1, fig. 19; Plate 3, fig. 45.

General coloration brown; antennæ short; cell M_2 open by the atrophy of the outer section of M_3; male hypopygium with both dististyles small; gonapophyses appearing as slender curved blades, each terminating in a blackened spine, the apophyses subtended by a long, slender, pale, lateral spine.

Male.—Length, about 4.5 millimeters; wing, 4.4.

Described from an alcoholic specimen.

Rostrum brownish yellow; palpi light brown. Antennæ (male) short, pale throughout; flagellar segments oval. Head brown, darker medially above.

Mesonotal præscutum chiefly light brown, the posterior sclerites of the mesonotum, together with the pleura, darker brown. Halteres yellow. Legs with the coxæ brown; trochanters yellowish brown; legs chiefly yellow or brownish yellow. Wings (Plate 1, fig. 19) yellowish gray, the stigmal region somewhat darker; veins slightly darker than the ground color, rather stout. Venation: Cell M_2 open by the atrophy of basal section of M_3; m-cu shortly before fork of M; vein 2d A gently sinuous on outer half.

Abdomen light brown, the caudal margins of the segments narrowly darker. Male hypopygium (Plate 3, fig. 45) with the dististyle, *d*, almost as in *O. takahashii* and *O. takeuchii*. Gonapophyses, *g*, very different, appearing as slender, curved blades, each terminating in a blackened spine; a long, slender, pale, lateral spine arising near the base of the apophysis.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Kibune, Kyoto Prefecture, altitude 750 feet, October 2, 1929 (*Tokunaga*).

This interesting *Ormosia* is named in honor of the collector, Dr. Masaaki Tokunaga. Allied to *Ormosia takahashii* Alexander and *O. takeuchii* Alexander, both of Japan, differing conspicuously in the structure of the male hypopygium.

ERIOPTERA (ILISIA) SUBAREOLATA sp. nov. Plate 1, fig. 20; Plate 3, fig. 46.

Belongs to the *areolata* group; allied to *sachalina;* legs yellow, only the terminal tarsal segments darkened; wings brownish yellow, the outer costal region darker; veins along cord infuscated; male hypopygium with the lateral arms of gonapophyses relatively stout.

Male.—Length, about 3.5 millimeters; wing, 4.

Rostrum brown; palpi black. Antennæ broken. Head pale brown, the anterior vertex light gray.

Mesonotum light brown, sparsely dusted with gray, the præscutum not variegated; pseudosutural foveæ and tuberculate pits chestnut-brown. Pleura light grayish brown. Halteres broken. Legs with the coxæ and trochanters testaceous yellow; remainder of legs yellow, the terminal tarsal segments darker. Wings (Plate 1, fig. 20) brownish yellow, the outer costal region more saturated; veins pale brown, the cord and outer end of cell 1st M_2 darker brown. Venation: Sc_1 ending opposite R_2; cell 1st M_2 small; m-cu about one-third its length before the fork of M; veins M_3 and M_4 deflected strongly cephalad at margin, vein Cu_1 less strongly so.

Abdominal tergites brown, the caudal margins of the segments pale yellow; sternites more uniformly yellow; hypopygium yellow. Male hypopygium (Plate 3, fig. 46) with the outer arm of the outer dististyle, *d*, only feebly blackened; intermediate arm simple. Lateral arms of gonapophyses, *g*, stouter than in *sachalina.*

Habitat.—China (Szechwan).

Holotype, male, Chengtu, altitude 1,700 feet, April 17, 1930 (*Franck*).

Erioptera (*Ilisia*) *subareolata* is most closely allied to *E.* (*I.*) *sachalina* Alexander (Saghalien), differing especially in the pattern of the legs and the slightly different male hypopygium, notably the feebly blackened outer arm of the outer dististyle and the stout lateral arms of the gonapophyses.

MOLOPHILUS ALBIREO sp. nov. Plate 1, fig. 21; Plate 3, fig. 47.

Belongs to the *gracilis* group and subgroup; general coloration dull black; antennæ (male) short; knobs of halteres dark brown; legs brownish black; wings with a strong blackish suffusion; costal fringe (male) conspicuous; male hypopygium with the ventral lobe of basistyle well developed, the dorsal lobe small, unblackened; both dististyles small and compressed.

Male.—Length, about 3.5 millimeters; wing, 4.

Rostrum and palpi black. Antennæ (male) short, black throughout; flagellar segments subcylindrical. Head dull black.

Anterior lateral pretergites light yellow. Mesonotum dull black, very sparsely pruinose; humeral region restrictedly brightened; pseudosutural foveæ and tuberculate pits black. Pleura dull black, sparsely pruinose, the dorsopleural membrane dark. Halteres brown, the knobs dark brown. Legs with the coxæ brownish black; trochanters brown; remainder of legs brownish black. Wings (Plate 1, fig. 21) with a strong blackish suffusion; veins and macrotrichia black. Costal fringe (male) relatively long and conspicuous, especially on distal half of wing. Venation: R_2 and r-m nearly in transverse alignment; vein 2d A ending about opposite the caudal end of m-cu.

Abdomen black. Male hypopygium (Plate 3, fig. 47) with the ventral lobe of basistyle, *b*, elongate, extending caudad beyond level of dististyle, armed with retrorse setæ; dorsal lobe small, unblackened. Dorsal dististyle, *dd,* a flattened blade; ventral dististyle, *vd,* with the inner angle prolonged.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 4,000 feet, August 16, 1930 (*Franck*).

Molophilus albireo belongs to a small aggregation of species with the lobes of the basistyle of the male hypopygium feebly developed and having no spinous points. The structure of the dististyles, together with the coloration, especially the dark halteres, readily suffice to distinguish it from *M. pegasus* Alexander, and other allied members of this group. The two dististyles of the unique type are superimposed on the slide and it is possible that their conformation is not entirely as figured.

MOLOPHILUS CYGNUS sp. nov. Plate 1, fig. 22; Plate 3, fig. 48.

Belongs to the *gracilis* group and subgroup; general coloration dark grayish brown; antennæ (male) short; halteres entirely light yellow; legs dark brown; wings with a pale brown tinge, the veins and macrotrichia dark brown; male hypopygium with the dorsal and mesal lobes of basistyle blackened, the former acute at tip; both dististyles entirely blackened, simple, the outer with four or five sharp teeth before tip.

Male.—Length, about 4 millimeters; wing, 4.5.

Rostrum testaceous brown; palpi black. Antennæ (male) short, dark brown throughout; flagellar segments subcylindrical, the terminal segment a little longer than the penultimate. Head light ocherous brown in front, more grayish behind.

Anterior lateral pretergites restrictedly yellowish. Mesonotum and pleura dark grayish brown, the latter somewhat paler on the dorsal sternopleurite. Halteres uniformly light yellow, clothed with golden-yellow setæ. Legs with the coxæ and trochanters yellow; femora brown, more yellowish brown basally; tibiæ and tarsi dark brown. Wings (Plate 1, fig. 22) with a pale brown tinge, the prearcular and costal regions, together with vein Cu_1 more yellowish; veins pale brown, more yellowish as above indicated; macrotrichia dark brown, more heavily grouped along cord. Costal fringe and macrotrichia of veins long and conspicuous. Venation: R_2 lying just distad of level of r-m; petiole of cell M_3 short, about one-third to one-half longer than m-cu; vein 2d A ending about opposite m-cu.

Abdomen dark brown. Male hypopygium (Plate 3, fig. 48) with the dorsal lobe of basistyle, *db,* slender, the extreme tip acute and heavily sclerotized; remainder of lobe with coarse setæ; mesal lobe slender, heavily blackened, appearing as a nearly straight rod, the apex rounded; ventral lobe, *vb*, large, spatulate, with erect to feebly retrorse setæ. Two dististyles, both simple, entirely blackened and strongly curved or sinuous, the outer, *od*, broader and provided with four or five sharp teeth immediately before the acute tip.

Habitat.—China (Szechwan).

Holotype, male, Kwanhsien, altitude 4,500 feet, August 13, 1930 (*Franck*).

Molophilus cygnus belongs to the section of the subgroup having short antennæ in the male sex, uniformly pale halteres, with the mesal lobe of the basistyle of hypopygium slender and heavily blackened, and with the dorsal lobe of basistyle acutely pointed at apex. The nearest regional allies seem to be the Formosan *M. arisanus* Alexander and *M. issikii* Alexander, in which the conformation of the mesal lobe of the basistyle and of both dististyles is entirely distinct.

ILLUSTRATIONS

[*a*, ædeagus; *b*, basistyle; *d*, dististyle; *db*, dorsal lobe of basistyle; *g*, gonapophysis; *ia*, inner arm of inner dististyle; *id*, inner dististyle; *oa*, outer arm of inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

PLATE 1

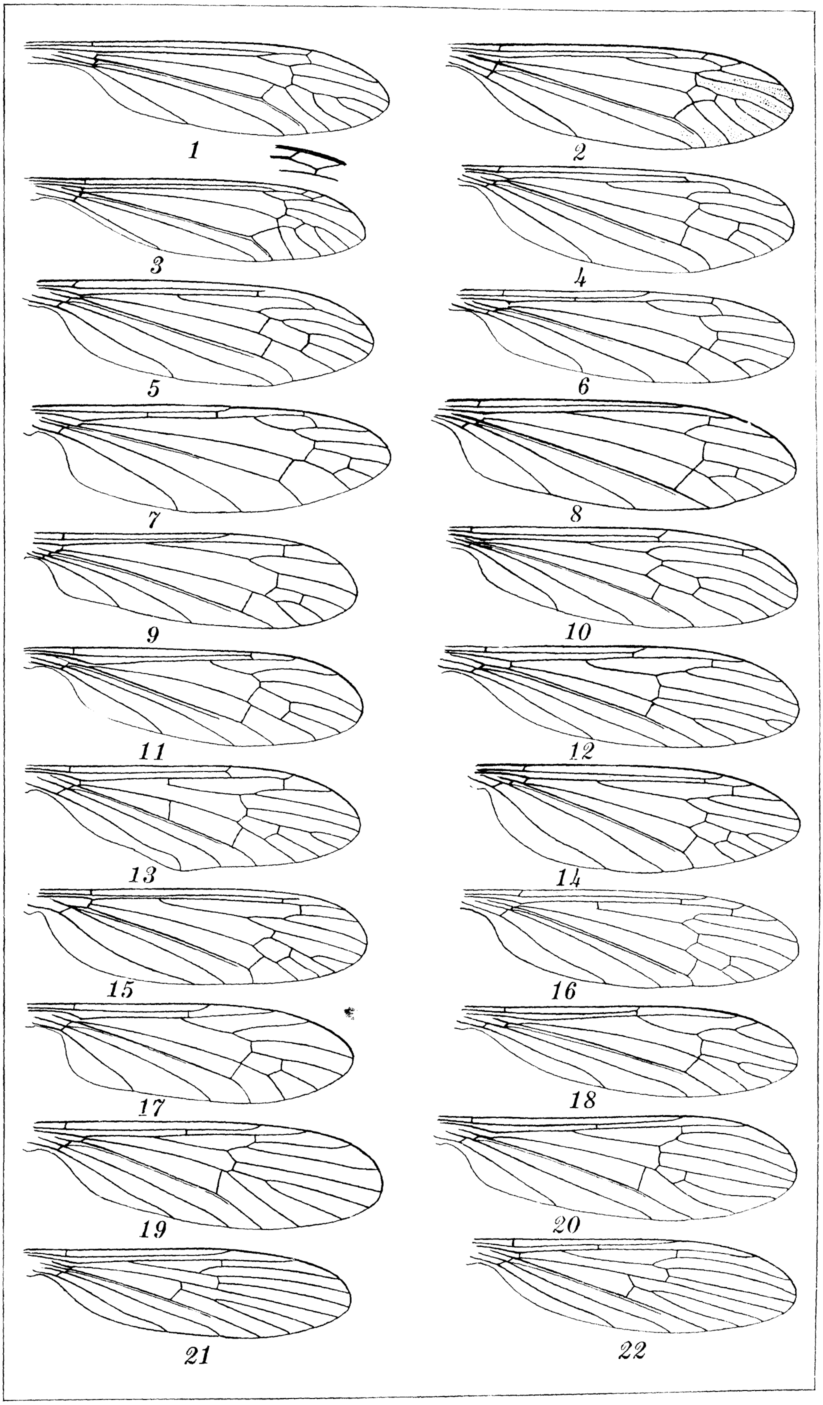
FIG. 1. *Dolichopeza* (*Nesopeza*) *francki* sp. nov., venation.
2. *Tipula seticellula* sp. nov., venation.
3. *Tipula* (*Tipula*) *okinawensis* sp. nov., venation.
4. *Liogma brevipecten* sp. nov., venation.
5. *Liogma fuscipennis* sp. nov., venation.
6. *Limonia* (*Dicranomyia*) *trifilamentosa* sp. nov., venation.
7. *Limonia* (*Idioglochina*) *tokunagai* sp. nov., venation.
8. *Proantocha quadrivittata* sp. nov., venation.
9. *Antocha sagana* sp. nov., venation.
10. *Dicranoptycha machidana* sp. nov., venation.
11. *Helius* (*Helius*) *pluto* sp. nov., venation.
12. *Polymera parvicornis* sp. nov., venation.
13. *Limnophila* (*Elæophila*) *serrulata* sp. nov., venation.
14. *Eriocera nigrotrochanterata* sp. nov., venation.
15. *Eriocera kelloggi* sp. nov., venation.
16. *Eriocera kamiyai* sp. nov., venation.
17. *Atarba* (*Atarbodes*) *bipunctulata* sp. nov., venation.
18. *Gonomyia* (*Gonomyia*) *subcognatella* sp. nov., venation.
19. *Ormosia tokunagai* sp. nov., venation.
20. *Erioptera* (*Ilisia*) *subareolata* sp. nov., venation.
21. *Molophilus albireo* sp. nov., venation.
22. *Molophilus cygnus* sp. nov., venation.

PLATE 2

FIG. 23. *Dolichopeza* (*Nesopeza*) *francki* sp. nov., male hypopygium.
24. *Tipula seticellula* sp. nov., male hypopygium, lateral.
25. *Tipula seticellula* sp. nov., male hypopygium, ninth tergite.
26. *Tipula seticellula* sp. nov., male hypopygium, dististyles.
27. *Tipula seticellula* sp. nov., male hypopygium, gonapophysis.
28. *Tipula seticellula* sp. nov., male hypopygium, eighth sternite.
29. *Tipula* (*Tipula*) *okinawensis* sp. nov., male hypopygium, details.
30. *Tipula* (*Vestiplex*) *divisotergata* sp. nov., male hypopygium, details.
31. *Liogma brevipecten* sp. nov., antenna, basal six flagellar segments.
32. *Liogma fuscipennis* sp. nov., antenna, basal five flagellar segments.
33. *Limonia* (*Dicranomyia*) *trifilamentosa* sp. nov., male hypopygium.
34. *Limonia* (*Idioglochina*) *tokunagai* sp. nov., male hypopygium.
35. *Antocha sagana* sp. nov., male hypopygium.

PLATE 3

FIG. 36. *Dicranoptycha machidana* sp. nov., male hypopygium.
37. *Helius* (*Helius*) *pluto* sp. nov., male hypopygium.
38. *Polymera parvicornis* sp. nov., male hypopygium.
39. *Limnophila* (*Elæophila*) *serrulata* sp. nov., male hypopygium.
40. *Limnophila imanishii* sp. nov., antenna, female.
41. *Atarba* (*Atarbodes*) *bipunctulata* sp. nov., male hypopygium.
42. *Chionea nipponica* sp. nov., male hypopygium.
43. *Chionea araneoides* Dalman, male hypopygium.
44. *Gonomyia* (*Gonomyia*) *subcognatella* sp. nov., male hypopygium.
45. *Ormosia tokunagai* sp. nov., male hypopygium.
46. *Erioptera* (*Ilisia*) *subareolata* sp. nov., male hypopygium.
47. *Molophilus albireo* sp. nov., male hypopygium.
48. *Molophilus cygnus* sp. nov., male hypopygium.



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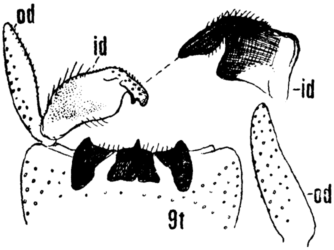

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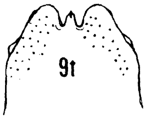

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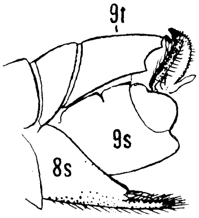

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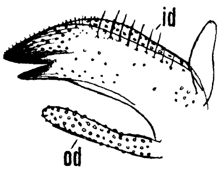

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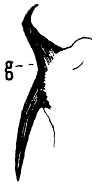

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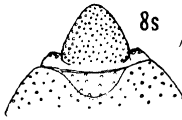

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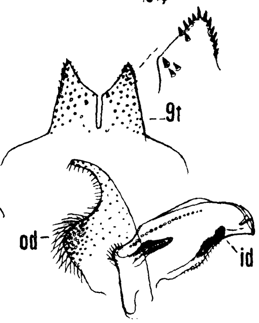

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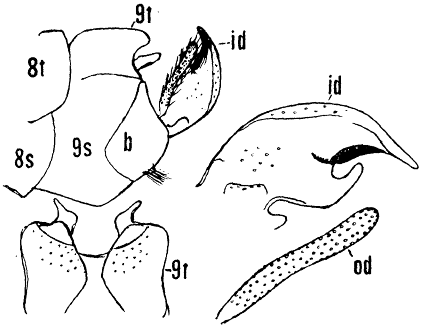

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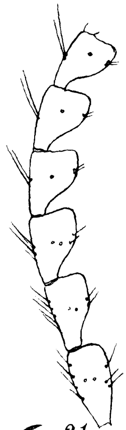

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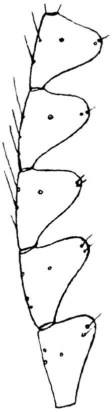

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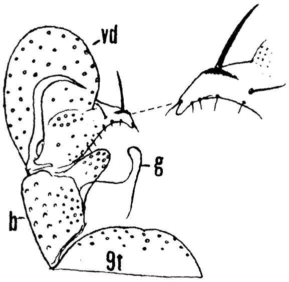

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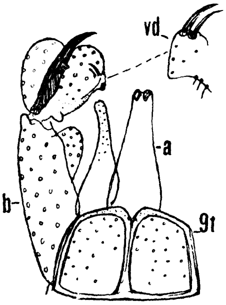

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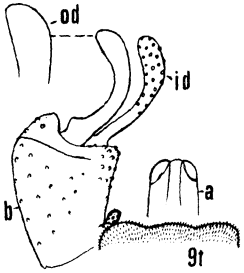

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PLATE 2.

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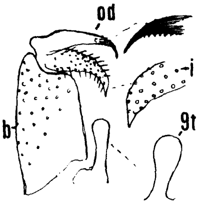

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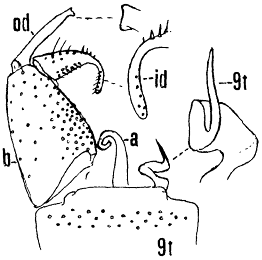

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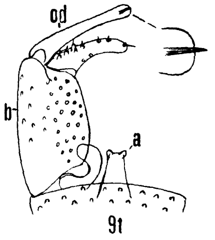

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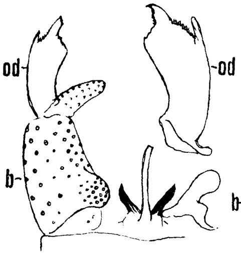

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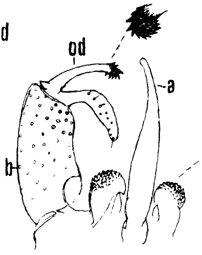

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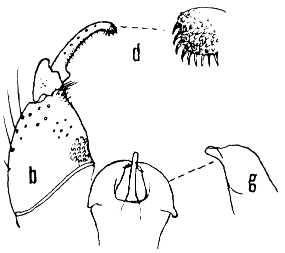

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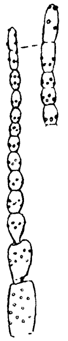

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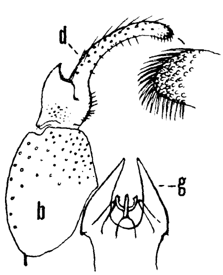

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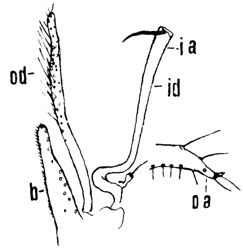

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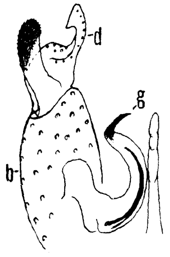

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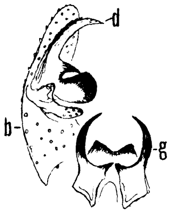

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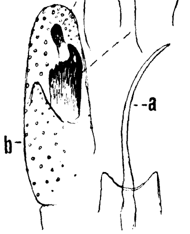

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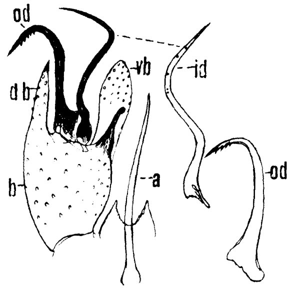

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THE PHILIPPINE
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VOL. 49 OCTOBER, 1932 No. 2

TERATOLOGY OF PHILIPPINE ORCHIDS [1]

By EDUARDO QUISUMBING
Botanist, Bureau of Science, Manila

THREE PLATES

In the course of studying Philippine orchids the author observed a number of abnormalities in orchid flowers, and it was thought best to record these observations as they were met. The present paper contains descriptions of a number of monstrosities in Philippine orchids which have been collected from time to time since 1931 by the author and his friends. In this connection the author desires to express his sincere thanks to Mrs. Remedios C. Gonzales and Mrs. K. B. Day, both of Manila.

ERIA BRACTESCENS Lindl. Plate 1; Plate 3, figs. 1 and 2.

Reversion, condensation, and suppression of floral organs are common teratological disturbances in Orchidaceæ, but the presence of two labella in a flower as far as the author is aware has not been reported in any *Eria*. *Eria bractescens* is common in the Philippines and is often sold in Manila by orchid peddlers. This particular plant had many flowers with two labella instead of one, grown together laterally.

PHALAENOPSIS APHRODITE Reichb. f.

Cases of fine pelories were reported by Costerus and Smith [2] in *Phalaenopsis amabilis* where the labellum and the petals are alike without any incision or appendage and the column wanting. Masters[3] also reported teratological cases in *Phalaenopsis schilleriana* and *P. amabilis,* but neither of them mentioned the kinds of pelories here described. The following deviations have been observed:

---

[1] The first paper on teratology of orchids was published by the author in Orchid Review 39 (1931) 131.

[2] Ann. Jard. Bot. Buitenzorg 28 (1914) 133, t. 26, fig. 14.

(1) One of the plants of *Phalaenopsis aphrodite,* collected by Mr. M. Ramos from Mount Iraya, Batanes, that flowered in the Bureau of Science orchid house, Manila, March 16, 1932, had a very peculiar column. All the floral segments were normal in size and form, with the exception of the column which was winged. The wing appeared like a petaloid organ (Plate 3, figs. 3 and 4).

(2) In the collections of Mrs. K. B. Day of *Phalaenopsis aphrodite* Reichb. f., there appeared a flower which was characterized by the complete suppression of the left petal (Plate 3, figs. 5 and 6). The absence of the left petal was accompanied by a slight increase in the size of the lateral sepals; the right petal present was normal. The labellum was normally developed. On the lateral side of the column there was an extra anther (Plate 3, fig. 6).

PHALAENOPSIS EQUESTRIS (Schauer) Reichb. f. Plate 3, figs. 7, 8, and 9.

The flower is dimerous and is about 2.8 cm across. The dorsal sepal, petals, and column are normally developed. The lateral sepals coalesced into one, in form quite like the dorsal sepal but larger. The coalesced structure is elliptic in shape and strongly concave at the tip. The specimen is also unique in the complete absence of the labellum. The specimen was collected from a plant belonging to Mrs. Remedios C. Gonzales.

PHALAENOPSIS SCHILLERIANA Reichb. f. Plate 2; Plate 3, figs. 10 and 11.

Cases similar to that in *Phalaenopsis aphrodite* (figs. 3 and 4) were observed in *Phalaenopsis schilleriana.* The wings here, however, were more developed, and appeared like a tumor enveloping the column as in fig. 11.

PHALAENOPSIS STUARTIANA Reichb. f. Plate 3, fig. 12.

This abnormality appeared in one of the many plants which flowered in the summer of 1932 in the Bureau of Science orchid house. At the base of the front lobe of the labellum an extra appendage or lobe was produced, linear-oblanceolate in form. The extra lobe was a chip of the front lobe and not of the lateral lobes.

[3] Vegetable Teratology (1869) 262.

SPATHOGLOTTIS PLICATA Blume. Plate 3, figs. 13 and 14.

Costerus and Smith[4] mentioned a case in this species showing transformation of petals into labella. The lateral sepals, the left petal, labellum, and column were all normal. The dorsal sepal, however, was intimately united with the right petal, forming a single structure, which was very cucullate.

VANDA SANDERIANA Reichb. f. Plate 3, figs. 15 and 16.

This is a case of synanthy of two flowers. The floral organs—petals, sepals, and labella—are slightly smaller than the typical and normal ones. The pedicel is single, but the ovary is forked. There are four petals, two dorsal sepals, four lateral sepals, and two columns.

[4] Ann. Jard. Bot. Buitenzorg 28 (1914) 134.

ILLUSTRATIONS

PLATE 1

Eria bractescens Lindl., racemes with double-lipped flowers, slightly reduced.

PLATE 2

Phalaenopsis schilleriana Reichb. f., flowers with winged columns, slightly reduced.

PLATE 3

FIG. 1. *Eria bractescens* Lindl., front view of flower with two lips, × 1.
2. *Eria bractescens* Lindl., side view of flower with two lips, × 1.
3. *Phalaenopsis aphrodite* Reichb. f., side view of column, × 2.
4. *Phalaenopsis aphrodite* Reichb. f., front view of column, × 2.
5. *Phalaenopsis aphrodite* Reichb. f., front view of a flower showing absence of one of the petals and enlargement of lateral sepals, × 0.5.
6. *Phalaenopsis aphrodite* Reichb. f., front view of column showing two fused anthers, × 2.
7. *Phalaenopsis equestris* (Schauer) Reichb. f., side view of flower, × 1.
8. *Phalaenopsis equestris* (Schauer) Reichb. f., front view of a flower, × 1.
9. *Phalaenopsis equestris* (Schauer) Reichb. f., view of fused lateral sepal from above, × 1.
10. *Phalaenopsis schilleriana* Reichb. f., front view of winged column, × 2.
11. *Phalaenopsis schilleriana* Reichb. f., front view of another winged column, × 2.
12. *Phalaenopsis stuartiana* Reichb. f., labellum stretched out, viewed from above, showing appendage, × 1.
13. *Spathoglottis plicata* Blume, front view of flower showing fused dorsal sepal and petal, × 1.
14. *Spathoglottis plicata* Blume, side view of flower, showing fused dorsal sepal and petal, × 1.
15. *Vanda sanderiana* Reichb. f., a double flower, × 0.5.
16. *Vanda sanderiana* Reichb. f., two labella and two ovaries with one single pedicel, × 0.5.

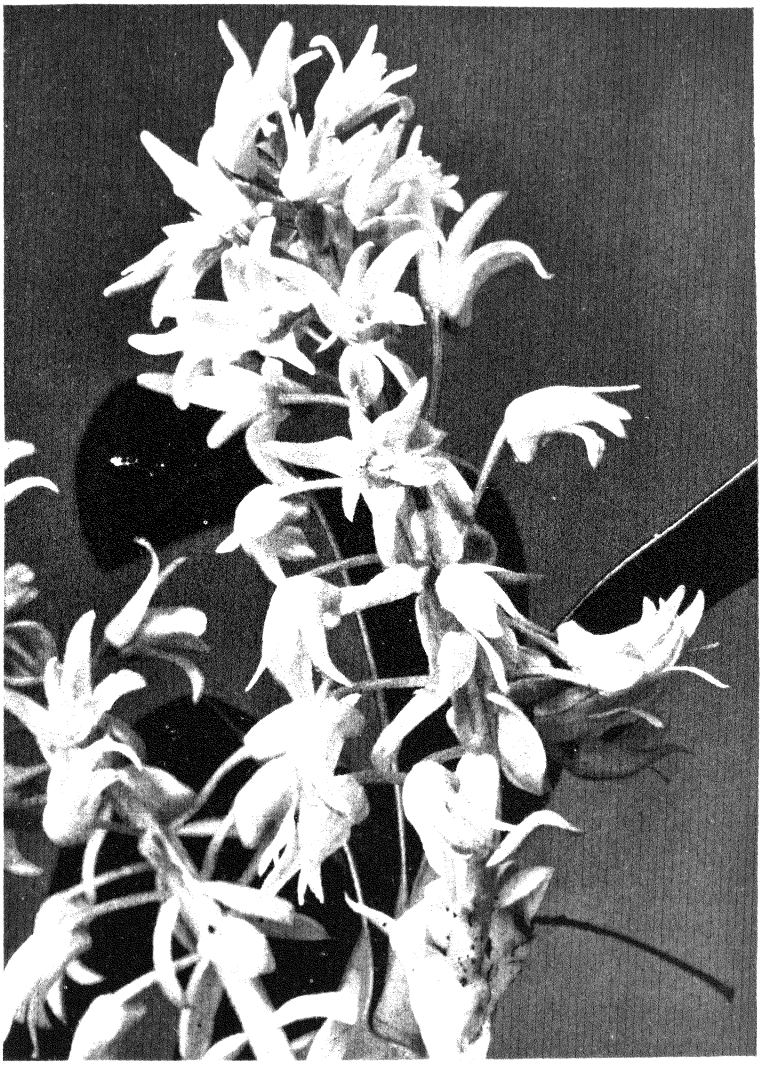
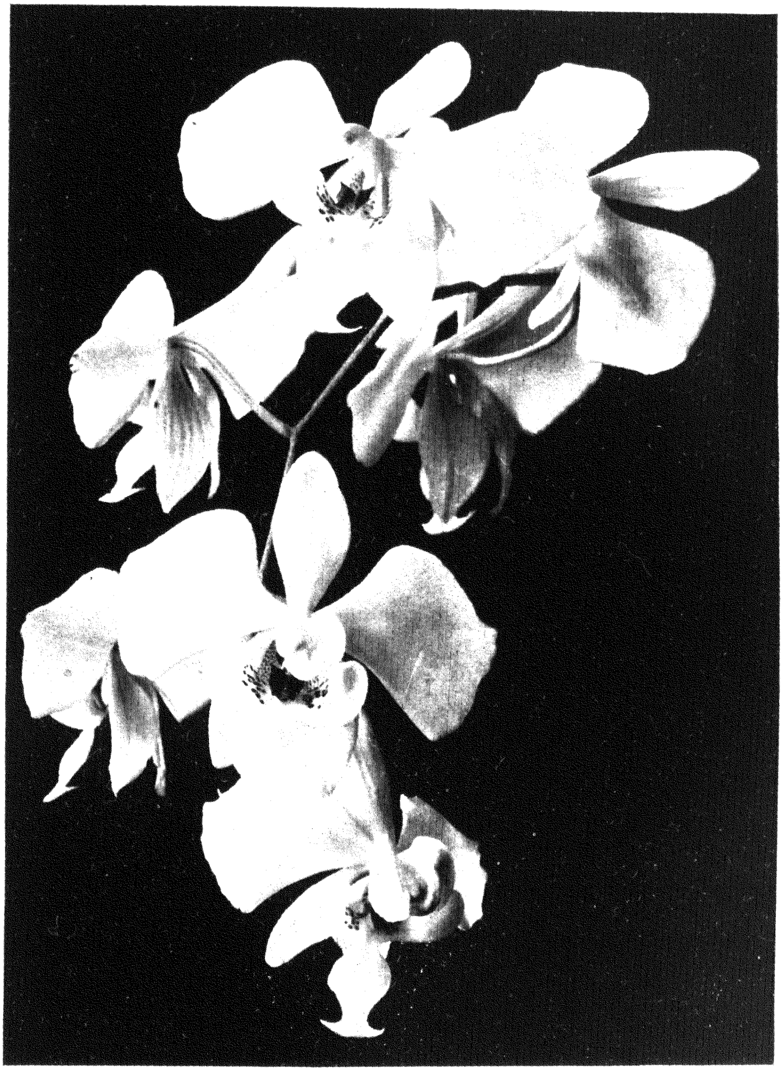


PLATE 1.



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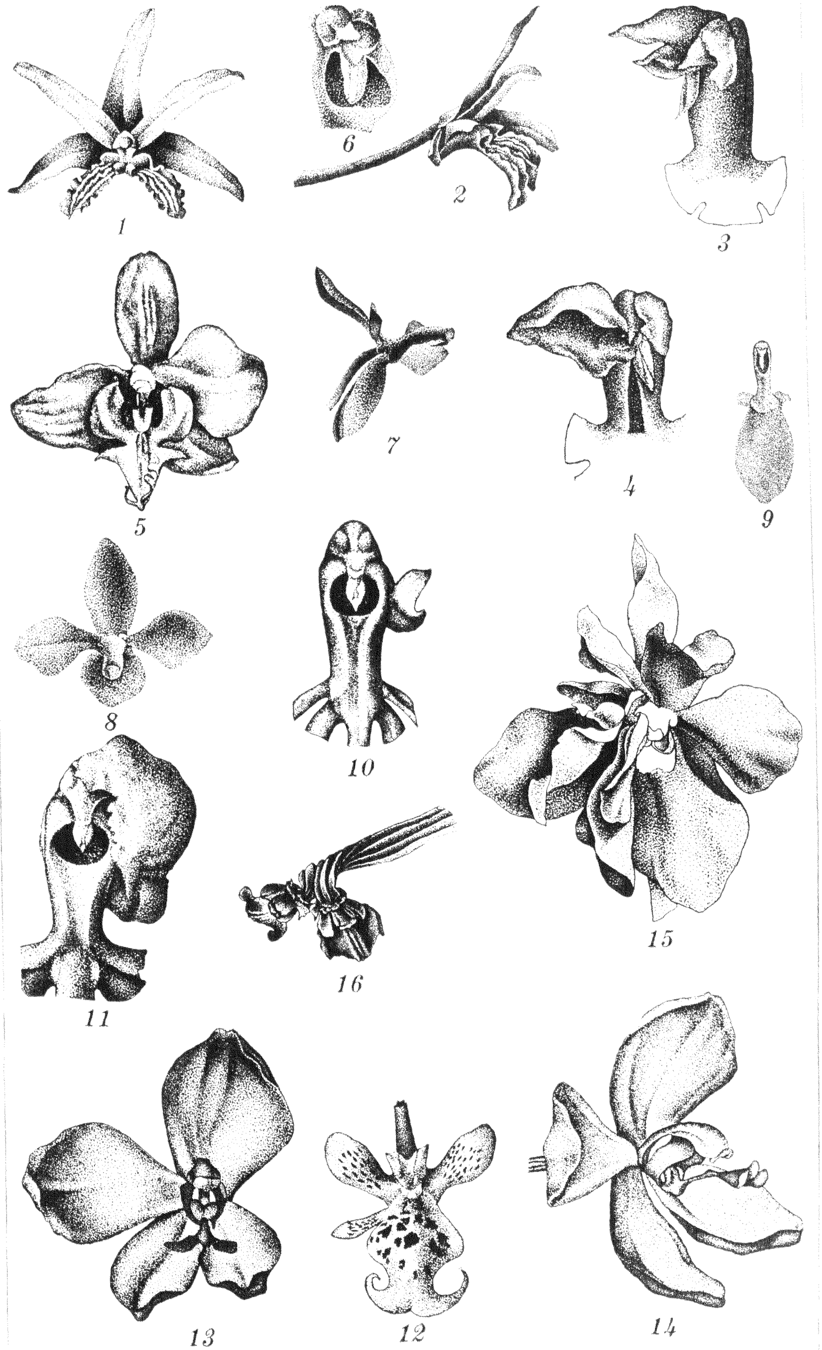

PLATE 3.

A MONOTYPIC PLANT ORDER NEW TO THE PHILIPPINE FLORA

By H. J. Lam

Botanist, Herbarium of the Botanic Gardens, Buitenzorg, Java

In 1909 the well-known plant collector A. D. E. Elmer discovered in the forests on the slopes of Mount Apo, Todaya, Davao district, Mindanao, Philippine Islands, a tree, which he considered to be a new species of the myrsinaceous genus *Discocalyx*. The plant was found "in ravines or upon ridges of secondary forests from 2,500 to 3,750 feet elevation" and described under the name *Discocalyx macrocarpa* Elmer,[1] being represented in various herbaria, and also in that of the Buitenzorg Botanical Gardens, by copies of its three type specimens; namely, *Elmer 10553* (flow. buds), *10660* (flow.), and *11867* (fruits).

Merrill[2] pointed out that, in his opinion, the species in question could not belong to the genus *Discocalyx*, since it showed many features in which it is quite different from the other species of that genus. He, therefore, proposed to raise it to generic rank and created the name *Apoia* for the new genus, the specific name thus becoming *Apoia macrocarpa* (Elm.) Merr. It seems worth while to quote Merrill's comment concerning this alteration:

> The original description is very long, yet several very important characters are not mentioned, these being the presence of staminodes alternating with the stamens; the 2-celled ovary, each cell with a single basal ovule; and the often 2-seeded fruit. The peculiar appendiculate-glandular petiole character is mentioned although this is not emphasized. At the junction with the lamina each petiole is provided with one, or more usually two,[3] rather stout, spreading or subappressed, appendaged glands, these often being 1 mm or more in length.

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[1] Leaflets of Philippine Botany Art. 115 8 (March 27, 1915) 2781–3.

[2] Philip. Journ. Sci. 17 (1920) 605–6.

[3] As far as I know there are, as may be expected, always two of such appendages, but only in two *Sarcosperma* species; namely, *S. paniculatum* Stapf and King and *S. breviracemosum* H. J. Lam.—H. J. L.

> I do not consider that the species can possibly be placed in *Discocalyx*, and it is so anomalous in the Myrsinaceae that I am by no means certain that it really belongs in this family, although in spite of its anomalous characters it seems to be better placed here than in any other group. The entire absence of the punctate glands in the vegetative[4] and floral organs; its 2-celled ovary, each cell with a single basal ovule; its ellipsoid, 2- or, by abortion, 1-seeded fruits; and its appendiculate-glandular petioles are anomalous characters in the Myrsinaceae, while staminodes are rare in the group, being confined to the quite unallied genus *Rapanea*. If it is properly placed in the Myrsinaceae, it is probably as close to *Discocalyx* as to any other proposed genus.

The same view is expressed in a later publication of the same author,[5] in which he retains the name *Apoia macrocarpa*, but with the addition: "A monotypic genus, perhaps, however, not belonging in this family."

In December, 1931, one of the ablest native clerks of the Buitenzorg Herbarium, Sapiin, to whose experience this institution owes many valuable indications, suggested that *Apoia* actually could not be placed in the Myrsinaceæ and asked whether it could be related with the Sarcospermaceæ. On comparing the specimens of *Apoia* with those of *Sarcosperma*, I elaborated several years ago,[6] it stood clear at once, as, for the rest, could have been evident from Merrill's observations, that *Apoia* must be identical with *Sarcosperma* and *Apoia macrocarpa* with *Sarcosperma paniculatum* Stapf and King. As to the differences from the Myrsinaceæ I may add to Merrill's points that the anthers are distinctly extrorse (Merrill says: "basifixae . . . . subintrorsae . . . ."), in the Myrsinaceæ they are always introrse—and that the leaves are often subopposite. The fact that *Sarcosperma* has been inserted not only in the Sapotaceæ, but also in the Myrsinaceæ, evidences both its close relation to those two families and its isolation from them, since its characters render it quite distinct from any genus in either of the orders mentioned.

---

[4] Some *Sarcosperma* species, such as *S. paniculatum* Stapf and King and *S. arboreum* Hook. f., possess small glands (pits) on the lower surface of the leaves, either dispersed or in the axils of the secondary nerves.—H. J. L.

[5] Enumeration of Philippine Flowering Plants. Manila **3** (1923) 270.

[6] Lam, H. J. The Sapotaceae, Sarcospermaceae and Boerlagellaceae of the Dutch East Indies and surrounding countries, Bull. du Jard. Bot. de Buitenzorg III **7** (1925) 248–250, fig. 64; Concise Revision of the Sarcospermaceae **8** (1926) 18–24, figs. 1–2.

The genus *Sarcosperma* was created by Hooker f., in 1876,[7] and thus invalidates *Apoia* (1920), as the specific name *macrocarpa* (1915) is invalidated by that of *paniculatum* (1901). Both genus and family are new to the Philippine flora. At present the Sarcospermaceæ are known to occur in southeastern Asia, continent (5 species, in China, Hong Kong, Tonkin, Assam, and Sikkim) and in the Malay Peninsula and Archipelago (4 species, in the Peninsula, Sumatra, Mindanao, and Ternate). *Sarcosperma paniculatum* is now known from the Malay Peninsula, Sumatra, Mindanao, and Ternate. Considering that the only other *Sarcosperma* species with the petiolar appendages—namely, *S. breviracemosum* H. J. Lam, which is known from Sumatra and Flores (Lesser Sunda Islands) only—differs from the first-named species only by its extremely small inflorescences and therefore possibly hardly deserves the specific rank next to *paniculatum,* we may, perhaps, suppose that *S. paniculatum* is one of those species which, covering a large area but nowhere being common, must be considered either as old forms that are due to disappear or, which in the present case seems to be more likely, as young and much-specialized (or reduced) forms which then possibly have to be supposed to originate polyphyletically from another (sapotaceous?) species.

I add a concise conspectus of the order, as far as the Philippines are concerned:

SARCOSPERMACEÆ

Sarcospermaceae H. J. LAM, Bull. Jard. bot. Buitenzorg III 7 (1925) 248. Monotypic.

Genus SARCOSPERMA Hooker f.

Sarcosperma HOOKER f., in Bentham and Hooker f., Gen. Pl. 2[2] (1876) 655; further literature in H. J. Lam, Bull. Jard. bot. Buitenzorg (1925 and 1927).

Bracea KING, Journ. As. Soc. Bengal 2, 54 (1896) 101.

Apoia MERRILL, Philip. Journ. Sci. 17 (1920) 605.

Nine species in southeastern Asia, continent, peninsula, and archipelago as far east as Mindanao, Ternate, and Flores.

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[7] In Bentham and Hooker f., Genera Plantarum 11[2]: 655.

In the Philippines only one species:

SARCOSPERMA PANICULATUM Stapf and King.

Sarcosperma paniculatum STAPF and KING, Icon. Plant. 7 (1901), tab. 2690; LAM, Bull. Jard. bot. Buitenzorg III 7 (1925) fig. 64.
Bracea paniculata KING, Journ. As. Soc. Bengal 2, 54 (1896).
Discocalyx macrocarpa ELMER, Leafl. Philip. Bot. 8 (1915) 2781.
Apoia macrocarpa (Elm.) MERRILL, Philip. Journ. Sci. 17 (1920) 605.

MINDANAO, Davao, Todaya, Mount Apo, 750 to 1,100 meters in altitude, *Elmer 10553; 10660; 11867.*

Distribution.—Malay Peninsula, Sumatra, Ternate, Mindanao.

DESMIDS FROM KOREA, JAPAN

By B. W. SKVORTZOW

Of Harbin, China

FIVE PLATES

The sixty-two desmids recorded in this paper were observed in collections of algæ kindly made for us by Dr. Tameso Mori, professor in Keijo Imperial University, in Korea, Japan, in Seiryori Lake near Keijo in 1926. The number of species is not great, but some are very interesting, conspicuous among which are *Cylindrocystis brebissonii* Menegh. var. *minor* West and G. S. West, *Cosmarium turgidum* Breb. var. *koreana* var. nov., and *Cosmarium willei* Turner.

CYLINDROCYSTIS BREBISSONII Menegh. var. **MINOR** West and G. S. West. Plate 1, fig. 1.

Cells cylindrical, unconstricted, length twice the diameter, apices rounded. Pyrenoids two. Length, 0.03 micron; breadth, 0.015.

GONATOZYGON KINAHANI (Arch.) Rabenh. Plate 1, fig. 2.

Cells twenty-five times longer than their diameter, cylindrical. Apices truncate, cell wall smooth. Length, 0.277 micron; breadth, 0.011.

NETRIUM NAGELII (Bréb.) West. Plate 1, fig. 3.

Cells about four times longer than their diameter, oblong-lanceolate, apices truncate. Length, 0.185 micron; breadth, 0.04.

PENIUM LIBELLULA (Focke) Nordst. Plate 1, fig. 4.

Cells large, six times longer than their diameter, fusiform, subtruncate apices. Cell wall smooth. Length, 0.25 micron; breadth, 0.042.

PENIUM MARGARITACEUM (Ehrenb.) Bréb. Plate 1, fig. 5.

Cells eight times longer than their diameter, subfusiform, constricted in the middle. Cell wall brown, granular. Length, 0.107 micron; breadth, 0.013.

PLEUROTAENIUM TRABECULA (Ehrenb.) Näg. Plate 1, fig. 6.

Cells large, fifteen to twenty times longer than their diameter; semicells with one or two basal inflations. Apices rounded, truncate with tubercles. Cell wall smooth, not punctate. Length, 0.43 to 0.5 micron; breadth at base of semicells, 0.017 to 0.022; breadth of apices, 0.0012 to 0.0015.

PLEUROTAENIUM TRABECULA (Ehrenb.) Näg. forma **CLAVATA** (Kütz.) West and G. S. West. Plate 1, fig. 7.

Cells about twelve times longer than their diameter. Semicells clavate. Length, 0.37 micron; breadth, 0.03; breadth of the apices, 0.015.

PLEUROTAENIUM sp. Plate 1, fig. 8.

Cells large, twenty-three times larger than their diameter. Semicells with a prominent basal inflation. Apices rounded-truncate, destitute of tubercles. Cell wall smooth. Length, 0.23 micron; breadth at base of semicells, 0.085; breadth of apices, 0.006.

CLOSTERIUM TURGIDUM Ehrenb. Plate 1, fig. 9.

Cells large, curved, eighteen times longer than their diameter with distinctly recurved apices. Cell wall finely striated. Length, 0.832 micron; breadth, 0.051; breadth of apices, 0.007.

CLOSTERIUM DECORUM Bréb. var. **MINOR** var. nov. Plate 1, fig. 10.

Cells sixteen times longer than their diameter, curved. Cell wall striated. Distance between apices, 0.173 micron; breadth, 0.011.

CLOSTERIUM INTERMEDIUM Ralfs. Plate 2, fig. 11.

Cells large, twenty-two times longer than their diameter, curved. Cell wall pale yellow, strongly striated. Length, 0.42 micron; breadth, 0.019; breadth of apices, 0.0074.

CLOSTERIUM STRIOLATUM Ehrenb. Plate 2, fig. 12.

Cells large, eight times longer than their diameter, slightly curved, inner margin straight. Apices broad and truncate with rounded angles. Cell wall yellowish, striated. Length, 0.307 micron; breadth, 0.037; breadth of apices, 0.009.

CLOSTERIUM TUMIDUM Jahnson var. **KOREANA** var. nov. Plate 2, fig. 13.

Cells eight times longer than their diameter, slightly curved. Cell wall smooth and colorless, chloroplasts with four ridges. Length, 0.259 micron; breadth, 0.029; breadth of apices, 0.006. This variety is distinguished from *Closterium tumidum* by the longer and broader cells.

CLOSTERIUM MONILIFERUM (Bory) Ehrenb. Plate 2, figs. 15 and 16.

Cells of medium size, seven times longer than their diameter. Cell wall smooth and colorless. Distance between apices, 0.24 micron; breadth, 0.038; breadth of apices, 0.001.

CLOSTERIUM LEIBLEINII Kütz. var. **BOERGESENII** Schmidle. Plate 2, fig. 17.

Cells of medium size, eleven times longer than their diameter. Cell wall smooth. Distance between apices, 0.236 micron; breadth, 0.02.

CLOSTERIUM PARVULUM Näg. var. **ANGUSTUM** West and G. S. West. Plate 2, figs. 18 and 19.

Cells small, ten times longer than their diameter, strongly curved. Cell wall smooth and colorless. Distance between apices, 0.076 to 0.095 micron; breadth, 0.0068 to 0.0085.

MICRASTERIAS DECEMDENTATA Näg. Plate 2, fig. 14.

Cells a little longer than broad. Semicells 5-lobed. Length, 0.064 micron; breadth, 0.061; breadth of isthmus, 0.0085.

EUASTRUM BINALE (Turp.) Ehrenb. forma **KOREANA** forma nov. Plate 3, fig. 20.

Cells minute, about 1.5 times longer than broad, deeply constricted, sinus narrowly linear; semicells subpyramidate, basal angles subrectangular, retuse-emarginate, superior angles apiculate. Cell wall smooth. Length, 0.018 micron; breadth, 0.013; breadth of isthmus, 0.0034.

EUASTRUM DUBIUM Näg. forma **KOREANA** forma nov. Plate 3, fig. 21.

Cells 1.2 times longer than broad, very deeply constricted. Semicells five-lobed; polar lobe short, oblong-rectangular, semicells with two granules. Length, 0.018 micron; breadth, 0.015; breadth of isthmus, 0.0042.

EUASTRUM INSULARE (Wittr.) Roy. Plate 3, fig. 22.

Cells minute, 1.5 times longer than broad, deeply constricted. Semicells three-lobed, subrectangular. Cell wall smooth. Length, 0.018 micron; breadth, 0.013; breadth of isthmus, 0.0034.

EUASTRUM INSULARE (Wittr.) Roy forma **MINUTA** forma nov. Plate 3, figs. 23 and 24.

Cells minute. Semicells somewhat three-lobed; upper half concave. Length, 0.012 to 0.013 micron; breadth, 0.001 to 0.012; breadth of isthmus, 0.0025 to 0.0035.

COSMARIUM OBSOLETUM (Hantzsch.) Reinsch. Plate 3, fig. 25.

Cells elliptic, deeply constricted, semicells semielliptic, basal angles submamillate. Cell wall punctate. Length, 0.03 to 0.047 micron; breadth, 0.032 to 0.047.

COSMARIUM PACHYDERMUM Lund var. **AETHIOPICUM** West and G. S. West. Plate 3, fig. 26.

Cells large, 1.2 times as long as broad, deeply constricted, semicells semielliptic, apices broad. Cell wall punctate. Length, 0.054 micron; breadth, 0.042; breadth of isthmus, 0.017.

COSMARIUM TRILOBULATUM Reinsch. Plate 3, fig. 27.

Cells small, 1.3 times longer than broad, deeply constricted, semicells three-lobed, smooth. Chloroplasts with one pyrenoid. Length, 0.025 micron; breadth, 0.017; breadth of isthmus, 0.005.

COSMARIUM ASPHAEROSPORUM Nordst. var. **STRIGOSUM** Nordst. Plate 3, figs. 28 and 29.

Cells small, about as long as broad, moderately constricted. Semicells broad-acuminate. Length, 0.01 micron; breadth, 0.0085; breadth of isthmus, 0.006.

COSMARIUM SINOSTEGOS Scharschm. var. **OBTUSUS** Gutw. Plate 3, fig. 30.

Cells minute, about 1.5 times as broad as long, deeply constricted. Semicells subhexagonal. Length, 0.012 micron; breadth, 0.01; breadth of isthmus, 0.004.

COSMARIUM MINIMUM West and G. S. West. Plate 3, figs. 31 and 32.

Cells minute, a little longer than broad, deeply constricted. Semicells rectangular. Length, 0.01 micron; breadth, 0.0085; breadth of isthmus, 0.0025.

COSMARIUM RECTANGULARE Grun. var. **KOREANA** var. nov. Plate 3, fig. 33.

Cells of medium size, 1.5 times as long as broad, deeply constricted. Semicells subhexagonal. Length, 0.015 to 0.017 micron; breadth, 0.01 to 0.011; breadth of isthmus, 0.0038 to 0.0042.

COSMARIUM PYGMAEUM Arch. Plate 3, figs. 34 and 35.

Cells small, about as long as broad or a little broader, deeply constricted. Length, 0.01 micron; breadth, 0.011; breadth of isthmus, 0.0025.

COSMARIUM ABBREVIATUM Rasib. Plate 3, fig. 36.

Cells small, 1.2 times longer than broad, deeply constricted. Semicells hexagonal. Length, 0.017 micron; breadth, 0.012; breadth of isthmus, 0.0042.

COSMARIUM UNDULATUM Corda var. **MINUTUM** Wittr. Plate 3, fig. 37.

Cells 1.5 times longer than broad, deeply constricted, semicells undulated. Length, 0.025 micron; breadth, 0.017; breadth of isthmus, 0.006.

COSMARIUM REGNESI Reinsch. Plate 3, fig. 38.

Cells small, about as long as broad, deeply constricted. Semicells rectangular with marginal teeth. Length, 0.01 micron; breadth, 0.009; breadth of isthmus, 0.003.

COSMARIUM PSEUDOARCTOUM Nordst. Plate 3, fig. 39.

Cells small, 1.2 times as long as broad, slightly constricted. Semicells widely subovate. Cell wall smooth. Length, 0.025 micron; breadth, 0.018; breadth of isthmus, 0.007.

COSMARIUM MONILIFORME (Turp.) Ralfs forma **PANDURIFORMIS** Heimerl. Plate 3, fig. 40.

Cells small, about twice as long as broad, slightly constricted. Semicells subcircular. Length, 0.022 micron; breadth, 0.009; breadth of isthmus, 0.007.

COSMARIUM SUBPROTUMIDUM Nordst. var. **GREGORII** (Roy and Biss.) West and G. S. West. Plate 3, fig. 41.

Cells nearly as broad as long, deeply constricted. Semicells trapeziform, subsemicircular. Cell wall with granules, marginal granules in pairs, conical. Length, 0.017 micron; breadth, 0.015; breadth of isthmus, 0.0045.

COSMARIUM PUNCTULATUM Bréb. var. **GRANULUSCULUM** (Roy and Biss.) West and G. S. West. Plate 3, fig. 42.

Cells a little longer than broad, deeply constricted. Semicells oblong-trapeziform rounded angles. Granules distributed over the whole surface. Length, 0.04 micron; breadth, 0.033; breadth of isthmus, 0.012.

COSMARIUM PUNCTULATUM Bréb. var. **SUBPUNCTULATUM** (Nordst.) Börg. Plate 3, fig. 43.

Cells a little longer than broad, very deeply constricted. Semicells oblong-trapeziform, basal angles rounded. Cell wall granulate. Length, 0.024 micron; breadth, 0.022; breadth of isthmus, 0.006.

COSMARIUM FURCATOSPERMUM West and G. S. West. Plate 3, fig. 44.

Cells small, a little longer than broad, deeply constricted. Semicells truncate-semicircular with two series of small granules. Vertical view elliptic. Length, 0.017 micron; breadth, 0.015; breadth of isthmus, 0.004.

COSMARIUM FURCATOSPERMUM West and G. S. West var. **KOREANA** var. nov. Plate 3, figs. 45 and 46.

Cells larger in size and granules more robust. Vertical view elliptic. Length, 0.03 to 0.032 micron; breadth, 0.027 to 0.028; breadth of isthmus, 0.0085.

COSMARIUM TURGIDUM Bréb. var. **KOREANA** var. nov. Plate 4, fig. 47.

Cells very large, 2.5 times as long as broad, slightly constricted. Semicells ovate-truncate, sides convex, apex rounded, punctate. Length, 0.2 micron; breadth, 0.073; breadth of isthmus, 0.06.

COSMARIUM SUBTURGIDUM (Turn.) Schmidle forma **MINOR** Schmidle. Plate 4, figs. 48, 49.

Cells 1.8 times as long as broad, slightly constricted. Semicells widely ovate, apex rounded. Cell wall punctate. Length, 0.076 to 0.099 micron; breadth, 0.041 to 0.042; breadth of isthmus, 0.04.

COSMARIUM WILLEI Turner. Plate 4, fig. 50.

Dysphinctium willei TURNER, in Freshwater Algae of East India, pl. 8, fig. 40.

Cells large, about twice as long as broad, moderately constricted. Semicells widely ovate from broad bases, apex subtruncately rounded. Cell wall furnished with emarginate verrucæ, disposed in regular vertical and horizontal series. Vertical view ovate. Length, 0.068 micron; breadth, 0.03; breadth of isthmus, 0.022. *Cosmarium willei* Turner was described from Bengal, northern India.

COSMARIUM LUNDELLII Delp. var. **CORRUPTUM** (Turn.) West and G. S. West. Plate 4, fig. 51.

Cells large, about as long as broad, deeply constricted. Semicells semicircular, basal angles broadly rounded, apex truncately rounded. Cell wall serobiculate. Length, 0.047 micron; breadth, 0.044; breadth of isthmus, 0.012.

COSMARIUM GEMINATUM Lund var. **ROTUNDATUM** Lütkemüller. Plate 4, fig. 52.

Cells as long as broad, deeply constricted. Semicells oblong and rounded, granulate. Vertical view elliptic, denticulate and warted. Length and breadth, 0.025 micron; breadth of isthmus, 0.0065; thickness, 0.015. This variety was described in 1900 from Ningpo Mountains, central China.

COSMARIUM PSEUDOPROTUBERANS Kirchn. Plate 4, fig. 53.

Cells small, a little longer than broad, deeply constricted. Semicells transversely subelliptic with obtuse lateral angles. Vertical view subelliptic. Cell wall punctate. Length, 0.023 micron; breadth, 0.02; breadth of isthmus, 0.005; thickness, 0.013.

COSMARIUM ORTHOSTICHUM Lund var. **COMPACTUM** West and G. S. West. Plate 4, fig. 54.

Cells as long as broad, deeply constricted. Semicells oblong-elliptic. Granules in vertical and horizontal series. Length and breadth, 0.02 micron; breadth of isthmus, 0.005.

COSMARIUM CONTRACTUM Kirchn. forma **JACOBSENII** (Roy) West and G. S. West. Plate 4, figs. 55 and 58.

Cells about 1.5 times longer than broad, deeply constricted. Semicells subelliptic. Length, 0.025 micron; breadth, 0.017; breadth of isthmus, 0.005.

COSMARIUM VEXATUM West. Plate 4, fig. 56.

Cells a little longer than broad, very deeply constricted. Semicells pyramidate. Granules sparse and subconcentrically arranged. Central area smooth. Length, 0.039 micron; breadth, 0.034; breadth of isthmus, 0.011.

COSMARIUM SUBTUMIDUM Nordst. Plate 4, fig. 57.

Cells about 1.2 times as long as broad, deeply constricted. Semicells pyramidate-semicircular, basal angles rounded. Cell wall minutely punctate. Length, 0.033 micron; breadth 0.024; breadth of isthmus, 0.011.

ARTHRODESMUS CONVERGENS Ehrenb. Plate 5, fig. 59.

Cells 1.2 times broader than long, very deeply constricted. Semicells elliptic, lateral angles furnished with a short spine. Length, 0.029 micron; breadth, 0.037; breadth of isthmus, 0.006.

ARTHRODESMUS PHIMUS Turn. var. **KOREANA** var. nov. Plate 5, fig. 61.

Cells small, about 1.3 as long as broad, deeply constricted. Semicells subhexagonal, sides slightly concave, apex truncate, lateral angles each with a small, short, diverging spine. Side view of semicell subcircular-depressed. Vertical view broadly fusiform-elliptic. Cell wall smooth. Length, 0.01 micron; breadth, 0.007; breadth of isthmus, 0.0045; thickness, 0.005.

XANTHIDIUM CONCINNUM Arch. var. **BOLDTIANA** West. Plate 5, fig. 60.

Cells minute, about as long as broad, deeply constricted. Semicells transversal subhexagonal, lateral angles each furnished with minute spines. Length and breadth, 0.01 micron; isthmus, 0.0025.

STAURASTRUM GRACILE Ralfs var. **NANUM** Wille. Plate 5, fig. 62.

Cells two times longer than broad, slightly constricted. Semicells cup-shaped, lateral margins slightly concave. Vertical view 4 to 5 angular. Length, 0.025 micron; breadth, 0.025 to 0.028; breadth of isthmus, 0.0045.

STAURASTRUM ALTERNANS Bréb. Plate 5, fig. 63.

Cells small, as long as broad, deeply constricted. Semicells oblong-elliptic. Vertical view triangular. Cell wall granulate. Length and breadth, 0.022 micron; breadth of isthmus, 0.007.

STAURASTRUM STIOLATUM (Nag.) Arch. Plate 5, fig. 64.

Cells small, about as long as broad, deeply constricted. Semicells oblong-elliptic, lateral angles rounded. Vertical view triangular, sides convex. Cell wall granulate. Length and breadth, 0.03 micron; breadth of isthmus, 0.011.

STAURASTRUM MUTICUM Bréb. Plate 5, fig. 65.

Cells a little longer than broad, deeply constricted. Semicells elliptic. Vertical view triangular with broadly rounded angles. Length, 0.022 micron; breadth, 0.02; breadth of isthmus, 0.0075.

STAURASTRUM VESTITUM Ralfs var. **KOREANA** var. nov. Plate 5, fig. 66.

Cells about 1.5 times broader than long, deeply constricted. Semicells subfusiform, apex slightly convex with about 6 emarginate spines. Vertical view triangular, with concave margins. Margins with 2 spines. Length, 0.037 micron; breadth, including process, 0.043; breadth of isthmus, 0.007.

STAURASTRUM GRANULOSUM (Ehrenb.) Ralfs. Plate 5, fig. 67.

Cells small, about as long as broad, deeply constricted. Semicells obsemicircular, apex slightly convex, lateral angles with a minute spine. Vertical view triangular. Length, 0.022 micron; breadth, 0.018; breadth of isthmus, 0.007.

STAURASTRUM PARADOXUM Meyen var. **PARVUM** West. Plate 5, fig. 68.

Cells 1.3 times longer than broad, constriction deep. Semicells cup-shaped. Vertical view triangular. Length, 0.025 micron; breadth, 0.017; breadth of isthmus, 0.0042.

STAURASTRUM LEPTOCLADUM Nordst. var. **SINUATUM** Wolle forma **PLANUM** Smith. Plate 5, fig. 69.

Cells a little broader than long, including the processes. Constriction deep. Semicells rectangular, slightly campanulate at the base, upper angles produced to form long, strongly diverging processes. Vertical view fusiform. Length with processes, 0.04 to 0.042 micron; breadth, including processes, 0.0098 to 0.0049; breadth of isthmus, 0.005.

STAURASTRUM CONNATUM (Lund) Roy and Biss. Plate 5, fig. 70.

Cells small, about as long as broad, deeply constricted. Semicells subsemicircular, vertical margin very strongly convex, dorsal margin nearly straight, upper angles with long spines. Vertical view triangular. Length, without spines, 0.017 to 0.018 micron; breadth, 0.018 to 0.02; breadth of isthmus, 0.0035 to 0.004.

STAURASTRUM DILATATUM Ehrenb. Plate 5, fig. 71.

Cells small, about as long as broad, constricted. Semicells cuneiform, apex undulated, slightly rounded. Vertical view quadrangular. Cell wall granulate. Length and breadth, 0.028 micron; breadth of isthmus, 0.006.

STAURASTRUM QUADRANGULARE Bréb. Plate 5, fig. 73.

Cells small, about as long as broad. Semicells rectangular, angles with 4 spines each. Vertical view 4-angled. Length, 0.025 micron; breadth, 0.021; breadth of isthmus, 0.0085.

STAURASTRUM sp. Plate 5, fig. 74.

Cells about 1.5 broad as long, constriction deep. Semicells cup-shaped, upper angles of the cell produced to long processes, projecting horizontally. Cell wall granulate with a circle of long spines around the base of the semicells. Vertical view 3-angled. Length, 0.02 micron; breadth, 0.032.

SPONDYLOSIUM PAPILLOSUM West and G. S. West. Plate 5, fig. 72.

Cells small, united to form twisted filaments, destitute of a gelatinous sheath. Cells slightly longer than broad. Semicells elliptic with truncate apices. Length, 0.0085 micron; breadth, 0.01; breadth of isthmus, 0.005.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Cylindrocystis brebissonii* Menegh. var. *minor* West and G. S. West.
2. *Gonatozygon kinahani* (Arch.) Rabenh.
3. *Netrium nagelii* (Bréb.) West.
4. *Penium libellula* (Focke) Nordst.
5. *Penium margaritaceum* (Ehrenb.) Bréb.
6. *Pleurotaenium trabecula* (Ehrenb.) Näg.
7. *Pleurotaenium trabecula* (Ehrenb.) Näg. forma *clavata* (Kütz.) West and G. S. West.
8. *Pleurotaenium* sp.
9. *Closterium turgidum* Ehrenb.
10. *Closterium decorum* Bréb. var. *minor* var. nov.

PLATE 2

FIG. 11. *Closterium intermedium* Ralfs.
12. *Closterium striolatum* Ehrenb.
13. *Closterium tumidum* Jahnson var. *koreana* var. nov.
14. *Micrasterias decemdentata* Näg.
15. *Closterium moniliferum* (Bory) Ehrenb.
16. *Closterium moniliferum* (Bory) Ehrenb.
17. *Closterium leibleinii* Kütz. var. *boergesenii* Schmidle.
18. *Closterium parvulum* Näg. var. *angustum* West and G. S. West.
19. *Closterium parvulum* Näg. var. *angustum* West and G. S. West.

PLATE 3

FIG. 20. *Euastrum binale* (Turp.) Ehrenb. forma *koreana* forma nov.
21. *Euastrum dubium* Näg. forma *koreana* forma nov.
22. *Euastrum insulare* (Wittr.) Roy.
23. *Euastrum insulare* (Wittr.) Roy forma *minuta* forma nov.
24. *Euastrum insulare* (Wittr.) Roy forma *minuta* forma nov.
25. *Cosmarium obsoletum* (Hantzsch.) Reinsch.
26. *Cosmarium pachydermum* Lund var. *aethiopicum* West and G. S. West.
27. *Cosmarium trilobulatum* Reinsch.
28. *Cosmarium asphaerosporum* Nordst. var. *strigosum* Nordst.
29. *Cosmarium asphaerosporum* Nordst. var. *strigosum* Nordst.
30. *Cosmarium sinostegos* Scharschm. var. *obtusus* Gutw.
31. *Cosmarium minimum* West and G. S. West.
32. *Cosmarium minimum* West and G. S. West.
33. *Cosmarium rectangulare* Grun. var. *koreana* var. nov.
34. *Cosmarium pygmaeum* Arch.
35. *Cosmarium pygmaeum* Arch.
36. *Cosmarium abbreviatum* Rasib.
37. *Cosmarium undulatum* Corda var. *minutum* Wittr.

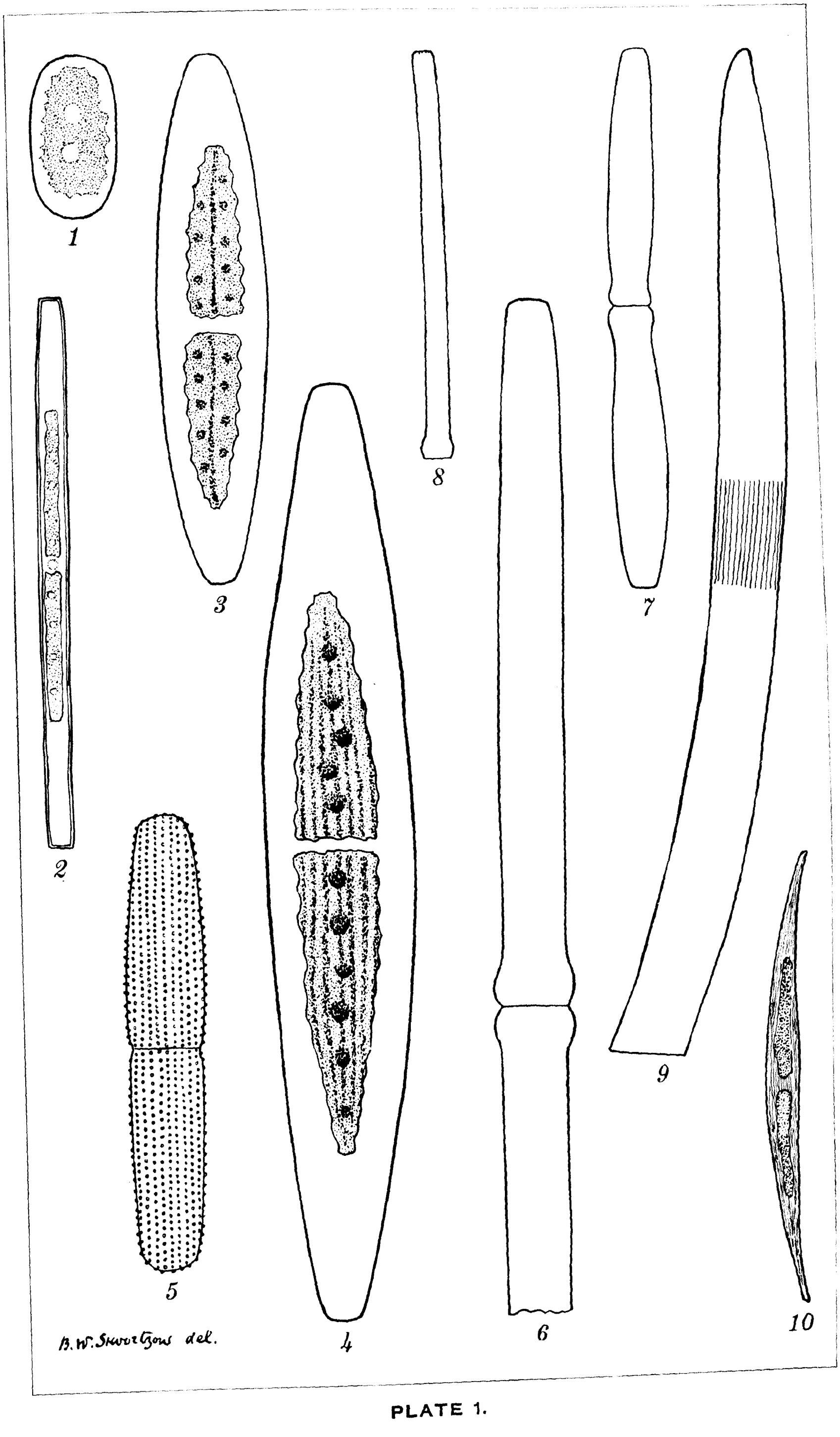
FIG. 38. *Cosmarium regnesis* Reinsch.
39. *Cosmarium pseudoarctoum* Nordst.
40. *Cosmarium moniliforme* (Turp.) Ralfs forma *panduriformis* Heimerl.
41. *Cosmarium subprotumidum* Nordst. var. *gregorii* (Roy and Biss.) West and G. S. West.
42. *Cosmarium punctulatum* Bréb. var. *granulusculum* (Roy and Biss.) West and G. S. West.
43. *Cosmarium punctulatum* Bréb. var. *subpunctulatum* (Nordst.) Börg.
44. *Cosmarium furcatospermum* West and G. S. West.
45. *Cosmarium furcatospermum* West and G. S. West var. *koreana* var. nov.
46. *Cosmarium furcatospermum* West and G. S. West var. *koreana* var. nov.

PLATE 4

FIG. 47. *Cosmarium turgidum* Bréb. var. *koreana* var. nov.
48. *Cosmarium subturgidum* (Turn.) Schmidle forma *minor* Schmidle.
49. *Cosmarium subturgidum* (Turn.) Schmidle forma *minor* Schmidle.
50. *Cosmarium willei* Turner.
51. *Cosmarium lundellii* Delp. var. *corruptum* (Turn.) West and G. S. West.
52. *Cosmarium geminatum* Lund var. *rotundatum* Lütkemüller.
53. *Cosmarium pseudoprotuberans* Kirchn.
54. *Cosmarium orthostichum* Lund var. *compactum* West and G. S. West.
55. *Cosmarium contractum* Kirchn. forma *jacobsenii* (Roy) West and G. S. West.
56. *Cosmarium vexatum* West.
57. *Cosmarium subtumidum* Nordst.
58. *Cosmarium contractum* Kirchn. forma *jacobsenii* (Roy) West and G. S. West.

PLATE 5

FIG. 59. *Arthrodesmus convergens* Ehrenb.
60. *Xanthidium concinnum* Arch. var. *boldtiana* West.
61. *Arthrodesmus phimus* Turn. var. *koreana* var. nov.
62. *Staurastrum gracile* Ralfs var. *nanum* Wille.
63. *Staurastrum alternans* Bréb.
64. *Staurastrum striolatum* (Näg.) Arch.
65. *Staurastrum muticum* Bréb.
66. *Staurastrum vestitum* Ralfs var. *koreana* var. nov.
67. *Staurastrum granulosum* (Ehrenb.) Ralfs.
68. *Staurastrum paradoxum* Meyen var. *parvum* West.
69. *Staurastrum leptocladum* Nordst. var. *sinuatum* Wolle forma *planum* Smith.
70. *Staurastrum connatum* (Lund) Roy and Biss.
71. *Staurastrum dilatatum* Ehrenb.
72. *Spondylosium papillosum* West and G. S. West.
73. *Staurastrum quadrangulare* Bréb.
74. *Staurastrum* sp.



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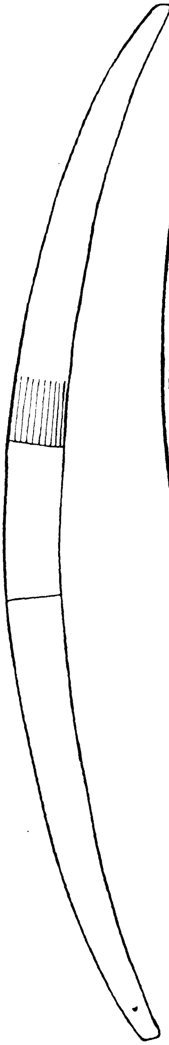

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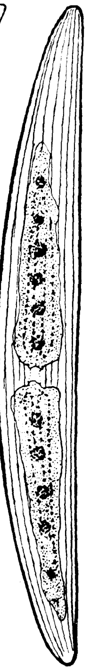

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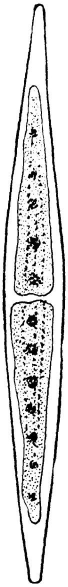

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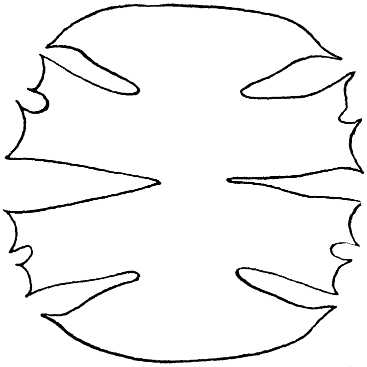

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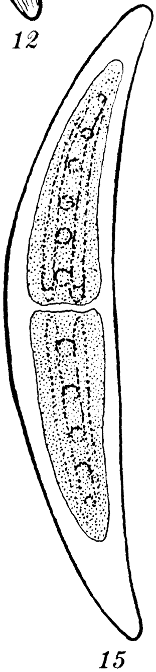

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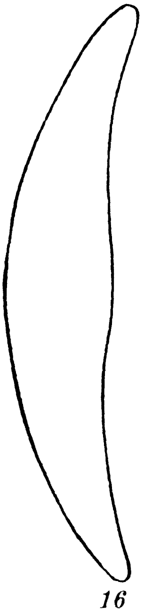

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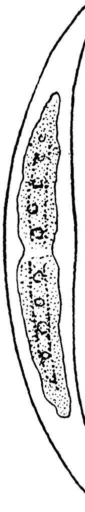

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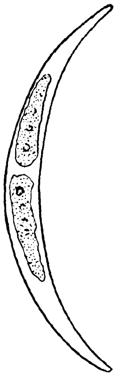

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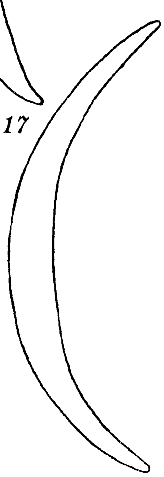

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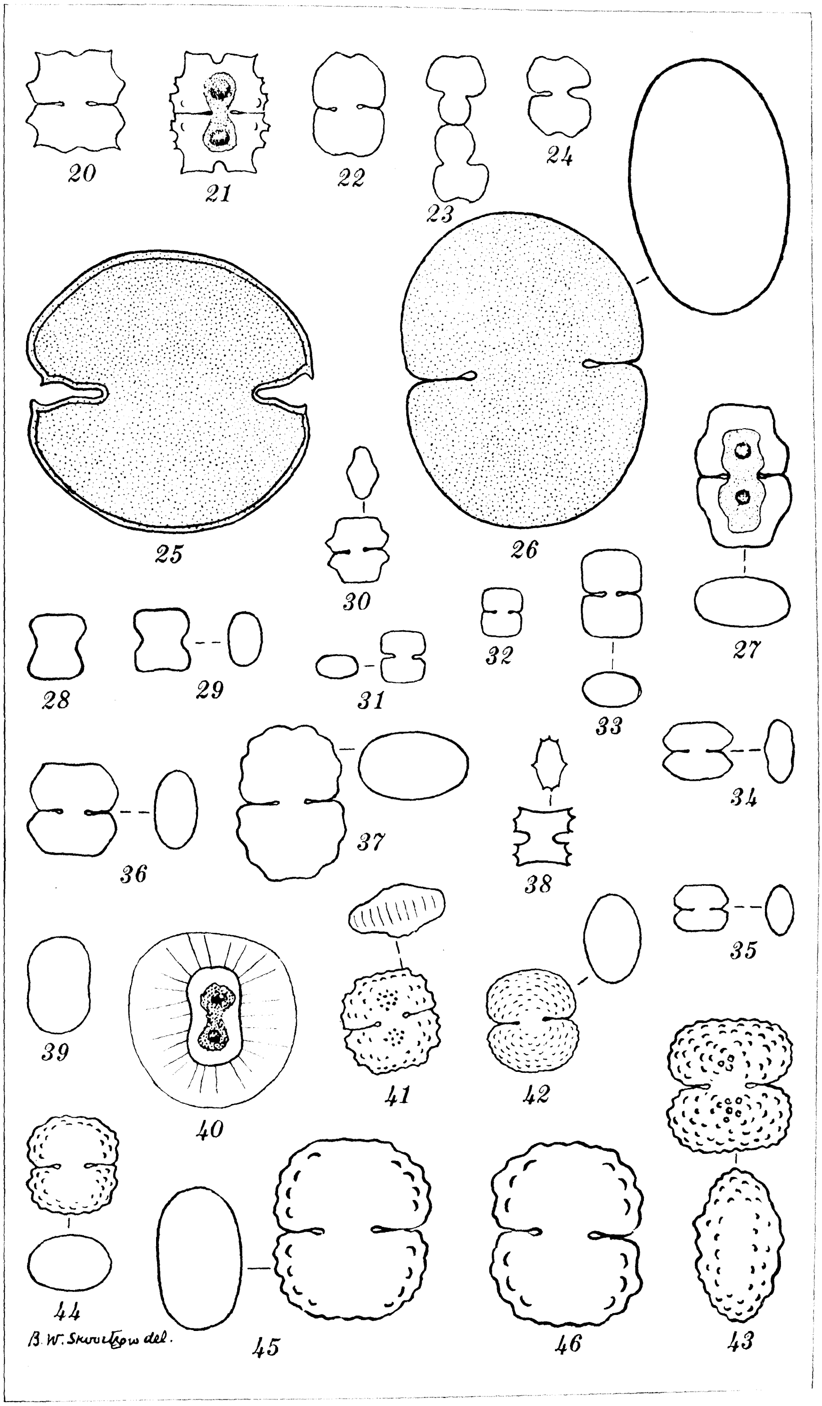
PLATE 2.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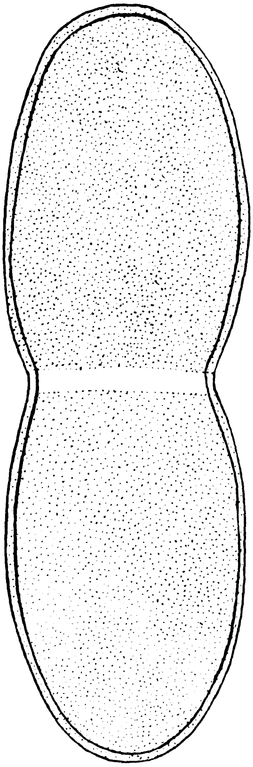

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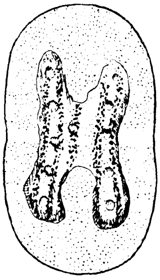

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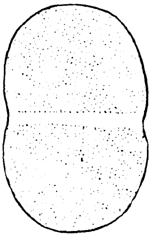

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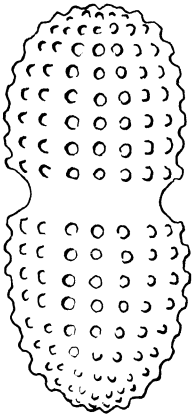

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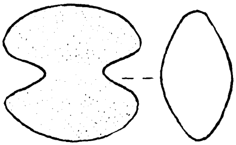

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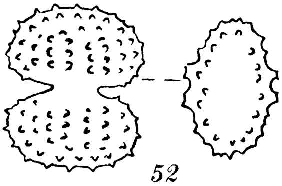

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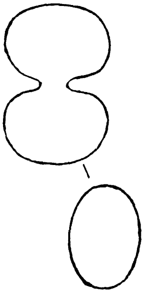

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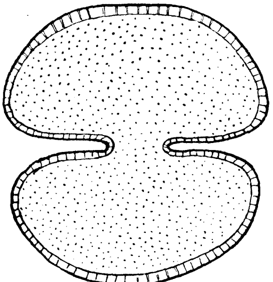

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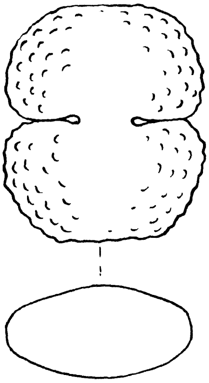

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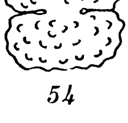

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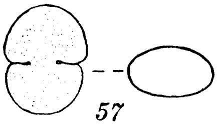

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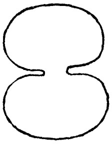

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PLATE 4.

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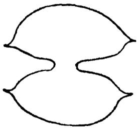
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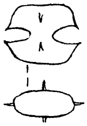
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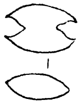
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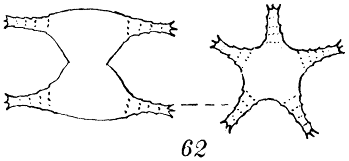
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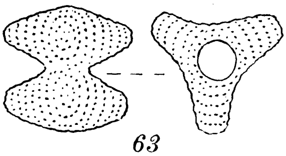
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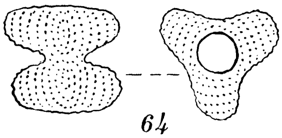
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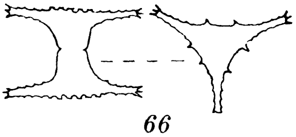
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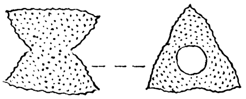
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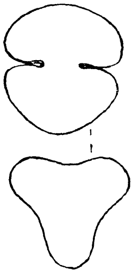
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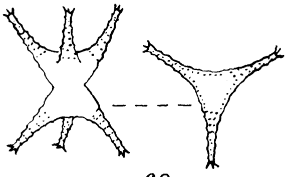
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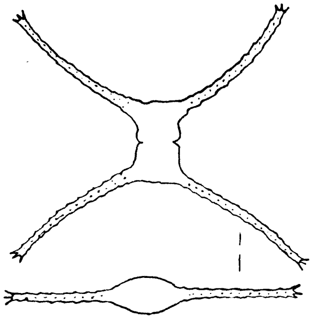
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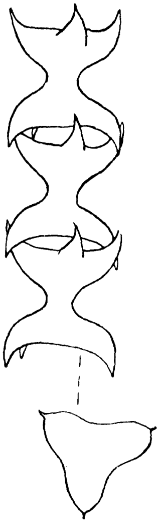
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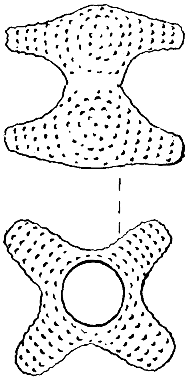
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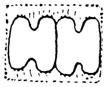
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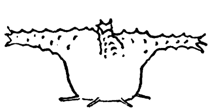
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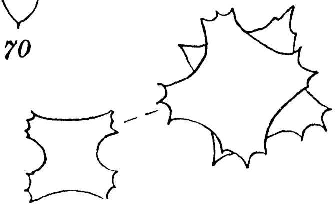
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PLATE 5.

STUDIES AND ILLUSTRATIONS IN THE POLYPORACEÆ, III

SUPPLEMENTARY NOTES ON THE GANODERMA APPLANATUM GROUP

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TWELVE PLATES

Since our preliminary paper[1] on this group was published we have had, through the courtesy of the Kew Herbarium and the Paris Museum of Natural History, the privilege of examining several of the older specimens or types, pertaining to the *applanatum* assemblage, concerning which we had expressed tentative opinions. Among the noteworthy specimens loaned by the Kew Herbarium were a fragment from the only authentic specimen of *Polyporus australis* Fries, a small segment from a large specimen which Miss Wakefield found agrees with the Friesian specimen as to spores, two small portions of an English specimen determined by Rea as *G. australe* (Fries), and the two collections of Elmer's Philippine Plants, *6943* and *7213*, cited by Murrill in his original description of *Ganoderma subtornatum* Murr. From the Paris Museum we received the types of *Polyporus testaceus* Léveillé, *Polyporus mastoporus* Léveillé, *Polyporus leucophaeus* Montagne, and an authentic specimen, or perhaps the type, of *Polyporus tornatus* Pers. collected by Gaudichaud in Rawak Island.

A study of these specimens in no way modifies the opinions expressed in the former paper but, rather, strengthens them. Notes and illustrations of such historic specimens, however, may prove of value to future workers in making interpretations within the group.

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[1] Philip. Journ. Sci. 45 (1931) 483-589.

TECHNIC

The technic followed was the same as in previous work; namely, microscopic measurements of hyphæ and spores were made with a 1/12a fluorite oil-immersion objective and 10x Huyghenian ocular, using a Leitz microscope, with a tube length of 160 millimeters, while colors of these elements were observed with a No. 6 (4-millimeter) objective and the same ocular; the colors being compared with Ridgway's color code. All mounts were made in 7 per cent potassium hydroxide by the methods formerly indicated. Unless otherwise stated ten measurements were made of the various elements. Photomicrographs of the spores were made with oil-immersion objective and 8x ocular.

GANODERMA AUSTRALE (FRIES)

In our previous paper we discussed this species from the standpoint of the literature. In a communication to the senior author Miss Elsie M. Wakefield, of the Kew Herbarium, states that to her knowledge the only Friesian specimen that exists is at Kew, but it is an insect-eaten specimen which has lost its outer crust, hence neither the nature of the crust nor the original thickness of the flesh can be determined. She states, however, that the spores are distinctly larger than in English specimens of *G. applanatum* but that she has an African form which seems to match it in that respect. We have studied both of these specimens, as well as English material determined by Rea, but in as much as the specimens loaned us were rather fragmentary we can only express general opinions concerning them.

The fragment of pores (Plate 5, fig. 1) of the authentic specimen shows nothing distinctive in coloration, being near Natal brown (R)[2] with continuous open tubes which average four to a millimeter. The orifices are pale brownish, almost circular, the walls appearing thick, equaling or exceeding the diameter of the tubes, even, and entire. The longisection, however, shows them much thinner walled within. The structure shows nothing distinctive, the dissepiments being made up of more or less interwoven hyphæ with a tendency to a longitudinal arrangement; the hyphæ varying in color from deep olive-buff, to dark olive-buff, the size ranging from 2.1 to 7.1 μ, with an average of 4.1 μ. A crushed mount gives pale spores (Plate

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[2] Ridgway, Robert, Color Standards and Color Nomenclature. Washington (1912).

12, fig. 1), which are near olive-buff, with rather fine but very distinct striæ, ranging in size from 7.3 to 8 μ by 10.6 to 12 μ, with an average of 7.7 by 11.1 μ. Dissepiment hyphæ (Plate 8, fig. 1; Plate 9, fig. 4) vary from 2.1 to 7.1 μ, with an average of 4.1 μ and vary in color from deep olive-buff to dark olive-buff.

Discussion.—The pores average somewhat larger, as expressed in number per millimeter, than in any of the species or varieties described in the earlier paper. In crushed mount the spores are more uniformly pale than in most of the collections so far examined in the *applanatum* group; they exceed all in maximum length and all but *lobatum* and *applanatum* var. *brownii* in maximum width, falling within the range for the latter. In average size they exceed all measurements so far made on *applanatum* and likewise fall within *applanatum* var. *brownii.*

From the data at hand it would appear that we are not dealing with a member of the *Ganoderma applanatum* group as discussed in our earlier paper. In *Ganoderma applanatum* var. *brownii,* although the spores are approximately the same size, they are, except in young specimens, considerably darker and more coarsely striate, which fact would make reference of *australe* to that variety rather doubtful. There can be no question about its being distinct from *Ganoderma tornatum* (Pers.).

The next specimen is a small segment (Plate 1, figs. 1 to 3) sent by Miss Wakefield, labelled "portion of a large specimen which seems to match Fries' as to spores, but has not specially thin flesh. Older specimens sent under the same number are less laccate and have a dull crust like applanatum, etc." The specimen is apparently the one stated in her letter as coming from Africa.

This marginal segment is 6.5 centimeters long, 2.7 centimeters thick at the base, applanate, broadly rounded above. Upper surface with three rather deep sulci, the ridges tuberculose except near the margin, near Natal brown (R), now dull, blackish where rubbed, apparently laccate when fresh, with a somewhat paler margin which is sterile beneath for 5 millimeters, dusted with cinnamon spores, glabrous behind but with minute pubescence at the margin. Crust indistinct, brown, not over 0.1 millimeter thick, lacking at the extreme margin, easily indented, finely but abundantly cracked, minutely wrinkled. Context 1.4 centimeters thick at the base, soft, spongy, felted, the fibers horizontal below but curving upward to the crust in the upper layer, with none of the harder streaks common in the *applanatum* group, narrowly but distinctly concentrically zoned, uniformly auburn (R) except for a slightly darker zone bordering the pores and a narrow lighter band just under the crust, this being pale tawny and less than 0.33 millimeter thick. Pores approaching brownish drab (R) but somewhat darker, in a single layer up to 1.5 centimeters thick, lined with loose hyphæ but not stuffed, usually four to the millimeter, with thin to medium thin dissepiments. Lower surface flavous, brownish tinged where bruised, with the pore orifices circular to subangular and the dissepiments of medium thickness, entire.

There is nothing distinctive in the structure (Plate 5, fig. 5). The dissepiment hyphæ (Plate 8, fig. 2; Plate 9, fig. 5) range in color from deep olive-buff to old gold and vary from 2.1 to 5.6 μ, with an average of 3.8 μ. The context hyphæ vary from old gold to a shade between honey yellow and Isabella color and range from 2.1 to 8.5 μ, with an average of 4.5 μ. The spores (Plate 12, fig. 2) from the upper surface range from 7.1 to 8.2 by 10.6 to 12.7 μ with an average of 7.4 by 11.4 μ, and vary from deep olive-buff to dark olive with moderately fine, distinct striæ. A radial section of the crust (Plate 6, fig. 5) shows a distinct palisade arrangement.

Discussion.—In comparison with the preceding specimen there are only slight differences as far as the elements are represented. The pores are flavous, whereas in the authentic specimen they are pale brown, but such variations often occur in various species. In the authentic specimen none of the darker spores are present and the striæ are somewhat finer. The spores, however, are essentially the same in size and only differ in these minor characters. It should be noted, however, that in the authentic specimen they were measured from a crushed mount of the pores while in the other they came from the upper surface and were, therefore, probably more mature. The darker dissepiment hyphæ tend more to dark olive-buff in the authentic specimen than to the more yellowish shade represented by the old gold of the African specimen. The lighter hyphæ are about the same color in both specimens.

The context is of the same dark color and consistency as in *Ganoderma sulcatum* Murr., but the spores differ much in character from that species. We have seen nothing to match it. It certainly does not belong in the *Ganoderma applanatum* assemblage, for in that group the crust does not show palisade structure, as it does in this one.

The third specimen from Kew, collected and determined by Rea, consists of a slice (Plate 1, figs. 4 and 5) of a lightweight fungus, which has become contracted and distorted in drying. The plant is rounded above, with a thin decurved margin, 8 centimeters long, 2.5 centimeters thick behind. The posterior portion of the upper surface is nearly black, with a suggestion of dark reddish, the anterior portion being dark reddish (approaching Ridgway's dark purple-drab), shining laccate behind, dull in front, deeply wrinkled in both directions but to a larger extent longitudinally. Margin black, sterile for 1 millimeter below. Context firm, almost woody, up to 7 millimeters thick behind, gradually tapering to the acute margin, longitudinally fibrous, cinnamon-brown (R) with a narrow cinnamon-buff (R) zone just beneath the crust; none of the harder streaks present. Lower surface medium brown, somewhat blackish discolored. Pores up to 2 centimeters long behind, becoming less than 1 millimeter at the margin, continuous, not layered, approaching snuff brown (R) in longisection, four, occasionally five, to a millimeter; dissepiments medium thick (Plate 5, fig. 3), somewhat eroded; orifices subangular to angular, somewhat occluded by an overgrowth of mold. Dissepiment hyphæ (Plate 8, fig. 3; Plate 9, fig. 6) near old gold, 2.1 to 5.9 μ, with an average of 3.7 μ. Context hyphæ vary from deep olive-buff to near old gold, 2.5 to 8.5 μ, averaging 4.5 μ. Spores (Plate 12, fig. 3) vary from olive-buff to deep olive-buff, with fine striæ, 6.3 to 7.8 by 8.7 to 11.3 μ, with an average of 7 by 10.3 μ. Crust (Plate 6, fig. 6) composed of long cylindric palisade cells.

Discussion.—While the writers have seen no authenticated specimens of *Ganoderma resinaceum* Boudier, it would appear from the descriptions available that the fungus may be closely related to that species or, perhaps, only a variant of it. It is also close to *Ganoderma sessile* Murr., although it differs from it considerably more in the context than is usual for that species. The spores, however, are essentially the same.

Fries's original description of *Polyporus australis* [3] calls for a plant with a very hard, dimidiate, plano-convex, pileus which is tuberculose-sulcate, glabrous, and blackish spadiceous above, with small pallid pores, umbrinous within, orifices whitish at first. He also stresses a broad, sterile, laccate margin on the underside and a thin context, and says that as the fungus ages the younger layers [of pores] become more and reduced, in consequence of which the older the fungus the wider the sterile margin and the narrower the hymenium [pore surface].

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[3] Elenchus 1 (1828) 108.

Although we have not seen any specimens of the *applanatum* group with a laccate margin this other condition is occasionally met with in specimens having thick vertically receding margins. In such instances the last pore surface is much smaller in area than the first layer laid down. Fries's original description would therefore fit what we consider variety *tornatum* Pers., with the exception of the laccate, sterile lower margin. In this description he only reports the fungus from islands of the Pacific Ocean, but later[4] he records it also throughout the Southern Hemisphere, with particular mention of Chile, and states that *Polyporus tornatus* Pers. is the same species. A still later description[5] is essentially the same as the preceding one, but with the addition "also noted in southern Europe, in Italy (de Notaris), and in lower Austria (Heufler)."

It thus appears that Fries departed considerably in his later work from his original concept of the species. It also appears that he may have confused two species in the original description, for a hard fungus of the character of *tornatum* would be a distinct novelty if provided with a laccate margin.

It is, therefore, doubtful whether the identity of the original *Ganoderma australe* (Fries) will ever be satisfactorily established. Most concepts and descriptions apply to a variant within the *applanatum* group. Fries himself considered it the same as Persoon's *Ganoderma tornatum,* which we have placed as a variety of *Ganoderma applanatum.* The fragments of the authentic specimen that we have just discussed, however, could not be referred there, for it has entirely different spores. It would appear best, therefore, to discontinue use of the name.

GANODERMA TORNATUM (PERS.)

The authentic specimen at hand from the Paris Museum bears the original label (Plate 1, fig. 8) "*Polyporus tornatus* v. *B. applanatus.* Rawak, Gaudichaud," without date. We have not had access to the original description,[6] but the specimen under consideration appears to be the type. It is small, 4.5 centimeters wide, 3.2 centimeters long, with a basal thickness of 0.9 centimeter (Plate 1, figs. 6 and 7). Upper surface (Plate 7, fig. 1) near chestnut-brown (R), somewhat blackened in spots from rubbing, glabrous or very nearly so, shallowly concentric sulcate. Margin subacute, concolorous. Lower surface nearly concolorous with the upper, with a narrow sterile blackened margin and blackened areas over the pore surface, particularly at the periphery. Pores (Plate 5, fig. 6; Plate 11, fig. 1) in a single layer, near dark vinaceous-drab in longisection, circular to subangular, 4.5 to 5 to a millimeter, up to 6 millimeters long behind, usually moderately thin walled but thick walled in certain areas; dissepiments entire. Context fibrous, up to 3.5 millimeters thick behind, varying from near Mikado brown (R) above to chestnut (R) below, obscurely concentrically zoned. The hard black streaks characteristic of the species were only noted at the extreme posterior portion, since the context was only exposed in a plane nearly paralleling the area of attachment. In crushed mount the spores (Plate 12, fig. 4) vary from olive-buff (R) to dark olive-buff (R), with coarse distinct striæ. They range from 4.9 to 5.6 by 6.8 to 7.8 μ, with an average of 5.3 by 7.1 μ. Both dissepiment hyphæ (Plate 8, fig. 4; Plate 9, fig. 7) and context hyphæ vary from deep olive-buff to old gold and show an average diameter of 4.2 μ, the former ranging from 2.1 to 7.8 μ, and the latter from 2.1 to 8.5 μ. Moderately thin-walled and thick-walled hyphæ are intermixed.

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[4] Epicrisis (1836–38) 464.

[5] Hymenomycetes Europaei (1874) 556.

[6] Gaudichaud-Beaupré, Charles, Botanique du voyage autour de monde par ordre du roi sui les corvettes l'Uranie et la Physcienne pendant les années 1817–1820 par M. Louis de Freycinet. Paris (1826) 173.

Discussion.—Although small and of only a single season's growth the specimen can readily be matched with many others recorded under variety *tornatum* in the previous paper. The spores average a little smaller than usual, but this can readily be accounted for by the two factors just mentioned.

A specimen of variety *tornatum* was sent us by the Paris Museum with the data "*Fomes australis* Fr., Brésil, Environs de Rio de Janeiro." The packet contains also a specimen of *Fomes marmoratus* Berk. The *tornatum* specimen (Plate 1, figs. 9 to 11) throws further light on that variety in the American Tropics, for variety *tornatum* is predominantly an inhabitant of the Eastern Hemisphere. The senior author has eight collections of the *applanatum* group from Brazil, six of which were placed in *applanatum* in the former paper, but none of them were referable to variety *tornatum*. The specimen that we here consider variety *tornatum* is quite close to Oriental material in general appearance, although the spores are not so coarsely striate. They are smaller, however, than in all other

Brazilian specimens so far examined and readily fall within the range of the variety.

The upper surface is broadly convex, lightly concentric sulcate, glabrous, Verona brown (R), dusted with spores, with a dark brown to blackish crust 0.25 to 0.5 millimeter in thickness, somewhat cracked. Context about 8 millimeters thick behind, tapering to 2 millimeters, firm corky, obscurely concentrically zonate, fibrous, with hard black streaks extending to near the margin, somewhat darker than russet (R) with a narrow auburn (R) line next to the pores and suggestions of Sayal brown (R) just under the crust (Plate 7, fig. 2). Lower surface approaching cinnamon-drab (R), benzo brown (R) where bruised, with a 2-millimeter, somewhat raised, sterile margin. Pores in longisection cinnamon-drab (R) in three layers with no sterile tissue between, the longest 6 millimeters, most of them stuffed with a whitish substance, 4.5 to 5 to a millimeter, subangular to angular, with medium, nearly entire dissepiments.

Dissepiment (Plate 8, fig. 5; Plate 9, fig. 8) and context hyphæ near old gold, the former, 2.1 to 5.9 μ, averaging 3.5 μ; the latter, 2.1 to 6.3 μ, with an average of 3.9 μ. Spores from the crushed mount the same as those from the upper surface (Plate 12, fig. 5), which are deep olive-buff to dark olive-buff with moderately fine, distinct striæ, 5.4 to 5.9 by 7.8 to 8.7 μ, with an average of 5.6 by 8.4 μ.

Discussion.—Brazilian specimens offer several problems in varietal segregation, as evidenced by variety *testaceum.* Forms of *applanatum* with thin context, such as we usually have in variety *tornatum,* are well represented, but the general appearance and the spores of these specimens, many of which are even larger than in American and European material of *applanatum,* argue for their placement in the base species.

GANODERMA APPLANATUM (PERS.) PAT.

Two English specimens were received from Miss Wakefield which throw further light on European forms of this species. One of the specimens (Plate 2, figs. 1 to 3) is typically applanate, tuberculose, somewhat paler than wood brown (R) in front and between hair brown (R) and Chaetura drab (R) behind, obscurely zoned and somewhat sulcate. Context bay (R) next to the pores, pale russet above, firm corky, concentrically zoned, with inconspicuous fawn-colored streaks, but no hard black ones. Crust (Plate 7, fig. 4) brown, 0.66 millimeter thick, and hard behind, thinner in front, where it can be indented with moderate pressure of the thumb nail. Pores in two layers with a layer of sterile bay tissue varying from 0.5 to 4 millimeters thick between, up to 1.5 centimeters long behind, four to five to a millimeter, with moderately thin dissepiments, approaching cinnamon-drab (R) in longisection. Lower surface light grayish olive (R), bruising to near Natal brown (R), with a sterile tumid margin 5 to 7 millimeters wide. Pore orifices circular to subangular, with entire nearly even dissepiments.

Dissepiment (Plate 8, fig. 6; Plate 10, fig. 1) and context hyphæ near old gold, the former ranging from 2.5 to 5.6 μ, averaging 3.7 μ, the latter 2.5 to 7.1 μ, averaging 4.3 μ. Spores (Plate 12, fig. 6) in crushed mount rather small, olive-buff to dark olive-buff with moderately fine striæ, 6.3 to 7.1 by 8.5 to 9.6 μ, averaging 6.7 by 9.1 μ

Discussion.—This specimen is rather close to American material in appearance and structure. The presence of fawn-colored streaks in the context brings it into relationship with variety *philippinense* Humph., where this character is developed to a marked degree. In other respects, however, it is typical *applanatum*. It is interesting to note that the spores are much smaller than certain ones figured in the earlier paper (see Plate 32, fig. 5) from an English specimen. The ones intermixed with these, however, were approximately the same as the ones figured herein.

The second specimen sent was an unusual thick ungulate form (Plate 2, figs. 4 and 5) with essentially the same colorations as the other specimen, first year's growth somewhat tuberculose, near blackish mouse gray (R) above, followed by a second year's growth extending beyond the first and forming a thick rounded tumid margin between avellaneous (R) and wood brown (R), bruising to dark brown. Crust thin, blackish, firm, almost lacking over the second year's growth. Context corky, nearly 7 centimeters thick, near auburn (R), concentrically zoned, lacking radiate hard black streaks but with a hard black line paralleling the upper surface at a depth of 0.8 to 1.5 centimeters. Lower surface rather uneven, approaching olive-buff (R), cinnamon-drab (R) where bruised. Pores in two narrow layers separated by a sterile tissue layer up to 8 millimeters thick, maximum length 5 millimeters, three to four to a millimeter. Dissepiments of medium thickness in longisection, but appearing thick walled when viewed from the lower surface, entire; orifices circular to subangular.

Dissepiment (Plate 8, fig. 7; Plate 10, fig. 2) and pore hyphæ near old gold (R), the former 2.1 to 5.6 μ, averaging 3.6 μ, the latter 2.5 to 5.9 μ, with an average of 4.4 μ. Spores (Plate 12, fig. 7) from the upper surface deep olive-buff to dark olive-buff with moderately rough, distinct striæ, 6.3 to 7.1 by 8.7 to 9.9 μ, averaging 6.7 by 9.3 μ. Crust (Plate 7, fig. 3) not palisade in structure.

Discussion.—This specimen is very abnormal in respect to its ungulate character and approaches *Ganoderma applanatum* var. *brownii* Murr. in gross appearance, having the same character and color of context as younger specimens of that variety. The pores are somewhat larger, however, and the pore surface is lighter in color. The only character that really distinguishes it from the variety is the size of the spores, which in variety *brownii* averages 7.92 by 12.46 μ for those from the upper surface, and 7.6 by 11.62 μ for those in crushed mounts. The striæ in the variety are also usually coarser.

GANODERMA LEUCOPHÆUM (MONT.)

A specimen from the Paris Museum (Plate 1, figs. 12 to 15), labelled "Ganoderma leucophæum (Mont.) Pat., Ohio (Sullivant), ex typo Montagneano," was available for study. This is nearly whole, although somewhat broken away where broadly attached behind, 2.5 centimeters long, 4.5 centimeters wide, 1.5 centimeters thick at the attachment. Upper surface somewhat darker than cartridge buff (R) with obscure pale drab zonation, glabrous to the eye but minutely puberulent under a hand lens, nearly plane, somewhat uneven, with a rounded margin. Crust 0.5 millimeter thick or less, blackish in section. Context (Plate 5, fig. 2) considerably insect eaten, auburn (R) near the crust and approaching Vandyke brown (R) below, firm corky, felted, 7 millimeters thick. Lower surface a little lighter than Prout's brown (R) with a broad sterile, minutely puberulent margin 1 centimeter wide, which is strongly tinged with avellaneous (R). Pores in longisection concolorous with the pore surface, in a single layer, up to 7.5 millimeters long, with rather thick dissepiments, four to five to a millimeter. Orifices (Plate 11, fig. 2) circular to subangular, with walls nearly even, entire.

Dissepiment (Plate 8, fig. 8; Plate 10, fig. 3) and context hyphæ deep olive-buff to near old gold, the former 2.1 to 5.6 μ, averaging 3.5 μ; the latter 2.1 to 7.8 μ, with an average of 3.7 μ. Spores (Plate 12, fig. 8) from the crushed mount deep olive-buff to dark olive-buff, with moderately fine, distinct striæ, 4.9 to 5.9 by 7.1 to 8.5 μ, averaging 5.5 by 7.6 μ. Crust (Plate 7, fig. 5) not palisade.

Discussion.—Although small the plant is typical of much of the American material that is usually placed in *Ganoderma applanatum.* While the spores are somewhat shorter than the average for American specimens this is probably due to the fact that the specimen is young. In our opinion the broad sterile margin and the pale crust are certainly not sufficient for even varietal segregation. It is, therefore, best to place the species as a direct synonym of *Ganoderma applanatum* (Pers.) Pat.

GANODERMA SUBTORNATUM MURRILL

Our discussion of this species in the previous paper[7] led to the opinion that *Ganoderma subtornatum* Murr., would prove synonymous with *Ganoderma mastoporum* Lév. While we have been unable to study the type of *subtornatum,* we have had the opportunity of examining the two Elmer collections cited in the original description. These two collections vary widely in appearance, but when one studies a large series of *mastoporum,* as we have done, it would appear that they must be considered merely variants of it.

Elmer 7213, Palo, Leyte Island, Philippines, January, 1906, in the Kew Herbarium, consists of a single applanate specimen (Plate 2, figs. 6 to 8) formed of two closely coalescent pilei, 5.2 centimeters long, 13 centimeters wide, and 2.3 centimeters thick at the base. Upper surface broadly convex, strongly sulcate, slightly radiate ridged, with a subacute margin, dull laccate, glabrous, near dark purplish gray (R) except where covered with a wood brown (R) scurf, with a small umbo behind. Context auburn (R) next to the pores, shading into cinnamon (R) near the crust, with small whitish bleached areas tinged with pale buff, 1.5 centimeters thick at the umbo, then reducing to 7 millimeters, whence it gradually tapers to 2 millimeters at the edge, fibrous, corky, obscurely concentrically zoned, with harder black streaks extending from the base to over one-half the length. Crust (Plate 6, fig. 2) thin, blackish in section, 0.12 to 0.20 millimeter, moderately hard to indent with the thumb nail, extending over the margin to the pores. Lower surface slightly concave, nearly even, near dark vinaceous-drab (R) with a sharply delimited, somewhat raised, sterile band, 3 to 5 millimeters wide at the margin; also bordered by a blackish sterile band next to the wood. Pores (Plate 6, fig. 1) in longisection a little lighter than Natal brown (R), five to six to a millimeter, up to 8 millimeters long, with medium, entire, dissepiments. Orifices (Plate 11, fig. 5) circular to subangular, often arranged in more or less sinuous rows with the portion of the wall which is at right angles to the sinuous ridges somewhat depressed, giving the appearance of the pores being set in shallow valleys one pore in width.

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[7] Philip. Journ. Sci. 45 (1931) 504–506.

Dissepiment hyphæ (Plate 9, fig. 2; Plate 10, fig. 5) vary from deep olive-buff (R) to dark olive-buff, 2.1 to 6.3 μ in diameter, averaging 3.9 μ. Context hyphæ are near old gold, 2.1 to 8.5 μ and average 4.5 μ. Spores (Plate 12, fig. 11) are near deep olive-buff with moderately coarse, distinct striæ, 5.6 to 5.9 by 8.5 to 9.6 μ, averaging 5.7 by 9.0 μ.

Discussion.—This specimen can readily be matched with other Philippine collections and is fairly representative of *Ganoderma mastoporum* in the Islands. The type of *mastoporum* has now lost almost all of its context through insect attack, but what little remains is exactly the same in color and character as in *subtornatum.* The upper surface, however, is now dull and obscurely banded with smoke gray (R) and benzo brown (R) but the short stipe is blackened with the same dull blackish laccation as *subtornatum.* The principal difference lies in the character of the pore mouths, which are distinctly mammillate over most of the surface in *mastoporum;* toward one side, however, they tend to form in linear valleys as in *subtornatum.* This latter is the common condition in Philippine specimens, but it is not a specific character, since certain specimens in the *applanatum* group have a similar, though less-marked, pore formation.

The other collection, *Elmer 6943,* Mount Mariveles, Bataan Province, Luzon, November, 1904, is a small, nearly circular plant (Plate 3, figs. 1 to 3), 3 centimeters across, 1.5 centimeters thick, broadly attached at the vertex. Upper surface broadly convex, lightly sulcate, slightly radiate ridged, minutely tomentose, lightly dusted with spores, near snuff brown (R). Margin abrupt, nearly vertical for 5 millimeters, vertically ridged to a slight degree. Context corky, felted, about 7 millimeters thick at point of attachment, tapering to 1 millimeter at the margin, Verona brown (R) next to the pores, somewhat lighter above. Lower surface near Mars brown (R), slightly convex, with the vertical margin entirely circumscribing the pores. Pores (Plate 6, fig. 3) in longisection near cinnamon-drab (R), five to a millimeter, with the orifices (Plate 11, fig. 4) somewhat smaller than in *7213* but of the same general character. Some are obscurely mammillate, others have a linear arrangement in valleys, as in the other, but less distinct.

Dissepiment hyphæ (Plate 9, fig. 3; Plate 10, fig. 6) are near old gold, 2.1 to 7.1 μ, averaging 4.1 μ. Context hyphæ vary from dark olive-buff to near old gold, 2.5 to 8.5 μ, with an average of 4.5 μ. Spores from deep olive-buff to dark olive-buff with moderately coarse, distinct striæ. Those from crushed mounts (Plate 12, fig. 12) are the same as those from the upper surface (Plate 12, fig. 13), which measure 5.6 to 6.3 by 9.2 to 9.9 μ, averaging 5.9 by 9.6 μ. Crust (Plate 6, fig. 4) nonpalisade.

Discussion.—The specimen is a fairly close match for another Philippine collection from Todaya (2,800 feet), Davao Province, Mindanao, *E. B. Copeland 1223,* April, 1904, determined *Ganoderma mastoporum* by Lloyd. This specimen has a dorsally attached stipe, but otherwise they are very similar. The form is very unusual, however. In coloration, context, pores, and structure the two Elmer collections cited are very close and merely represent two forms of *mastoporum.* Elmer has distributed a number of other collections as *Ganoderma subtornatum,* however, which are referable to the *applanatum* group, principally *Ganoderma applanatum* var. *philippinense.* There is one collection on the Kew sheets, *Elmer 10756,* which is referable to *Ganoderma applanatum* var. *tornatum* forma *macrospora.* Bresadola erred in practically all of his determinations, for his namings for the Bureau of Science are largely *applanatum* var. *philippinense.*

GANODERMA TESTACEUM (LÉV.)

The type of this species in the Paris Museum bears the label "*Polyporus testaceus* Lév., *Brasilium Meridion.,* Dupré 1842" (Plate 3, fig. 14), and consists of four small specimens attached to a card. One of the specimens (Plate 3, figs. 4 and 5) represents the form stressed in the original description; namely, "in stipitem brevem crassum concolorem producto," but two are merely contracted to a narrow attachment (Plate 3, figs. 6 to 9). The stipe in the typical form is somewhat tuberculose, 2 centimeters long, 1.5 centimeters thick, 1.2 centimeters wide, depressed below the level of the pileus, and consists of an abrupt elongation of it. The same description, with the exception of the more-elongate stipe, applies to three of the specimens, with the exception that the two smaller nonstipitate forms are somewhat less tuberculose than the typical form. The stipitate form is 5.5 centimeters long, 4.3 centimeters wide, and 1.5 centimeters thick at the middle, the two nonstipitate specimens approximately 3 by 2.7 by 1.3 centimeters. The upper surface is convex, moderately to strikingly tuberculose, concentrically sulcate, dull, somewhat dusted with spores, somewhat lighter than snuff brown (R), blackened where rubbed, glabrous or very nearly so. Margin rounded to vertical, sulcate. Context fibrous felted, from Sayal brown (R) above to auburn (R) below, with a few inconspicuous harder blackish streaks extending about two-thirds the length, 6 millimeters thick behind, tapering and continuing the full length of the vertical margin as well as completely circumscribing the pores at the attachment of the pileus. Crust up to 0.4 millimeter thick, hard and blackish in section. Lower surface plane to slightly concave, varying from a little paler than wood brown (R) to snuff brown (R); blackish where bruised. Pores (Plate 5, fig. 4) in longisection completely circumscribed by the sterile margin, approaching benzo brown (R), up to 1 centimeter long, in a single layer, four to five to a millimeter. Dissepiments medium to thick, with even, entire edges. Orifices (Plate 11, fig. 3) circular to subcircular, occasionally subangular.

Both dissepiment (Plate 9, fig. 1; Plate 10, fig. 4) and context hyphæ vary from deep olive-buff to dark olive-buff, the former 2.1 to 5.6 μ, averaging 3.5 μ, the latter 2.1 to 9.2 μ, with an average of 4.4 μ. Spores from the crushed mount are near deep olive-buff, with moderately fine, distinct striæ, 5.4 to 5.9 by 7.8 to 9.2 μ, averaging 5.6 by 8.6 μ. Those on the upper surface (Plate 12, fig. 9) approach Sayal brown (R); under the microscope they appear the same as those from the crushed mount but a little larger, 5.6 to 6.3 by 8.5 to 9.6 μ, averaging 6.0 by 8.9 μ. Crust (Plate 7, fig. 6) nonpalisade in structure.

The fourth linguiform specimen (Plate 3, figs. 11 to 13) included in the type is a young, rather abnormal sporophore of *Fomes marmoratus* Berk., which is now considered a synonym of *Fomes fasciatus* (Sw.). It is very different in several features from the other specimens.

In our previous paper[8] we refer to two collections (Humphrey herbarium *11056*, *11059*), sent to the senior author from Brazil, that agree sufficiently well with the type to be referred to *testaceum*.

No. *11059* (Nova Petropolis, *J. Rick*, 1923) consists of six specimens (Plate 3, figs. 15 to 18), of which one is short stipitate and 1 centimeter thick, one is 1.2 centimeters thick and attached obliquely at the vertex. The other specimens are thin, two being contracted at the attachment, and ranging from 0.7 to 1.2 centimeters thick, while one forms a resupinate plaque 1 centimeter thick, broadly attached at the back; still another is resupinate and broadly attached and is about 7 millimeters thick, with the upper edge reflexed for 1.5 centimeters. The stipitate specimen has a broadly rounded margin, which is sulcate and almost vertical. In the others it is thin to moderately so. All specimens are sulcate, glabrous to minutely puberulent, the color lying between avellaneous (R) and wood brown (R), being somewhat lighter than in the type. The ultimate margin may be pallid or concolorous. The context is 1.5 millimeters thick in the smallest applanate specimen, 5 millimeters in the stipitate one, and matches that of the type almost exactly, although the concentric zonation is somewhat more distinct. The pores in longisection also match the type in size and color, but the orifices are occluded in most of the specimens. In the specimen attached at the vertex there appear to be two layers, very indistinctly separated. Under surface a very pallid brownish (not in Ridgway) bruising to fawn color (R), Natal brown (R), or darker.

Dissepiment and context hyphæ are near old gold, the former 2.2 to 5.2 μ, averaging 3.9 μ, the latter 2.2 to 6.0 μ, averaging 4.1 μ. Spores from the crushed mount olive-buff to deep olive-buff, with moderately fine, distinct striæ, 4.5 to 5.2 by 7.5 to 9 μ, averaging 4.8 by 8.7 μ.

No. *11056* (Parecy, *J. Rick*, 1924) is represented by three specimens, one of which is small, elongate and immature, one 5 by 2.5 by 1 centimeter, with a short stipe 7 millimeters long arising from the middle of the back at the rear, the other 7 by 3.2 by 1.5 centimeters, spathulate (Plate 3, figs. 19 and 20), gradually tapering into a down-curved stem 7 millimeters in diameter.

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[8] Op. cit. 527, pl. 4, figs. 1, 3, 8, 9.

Upper surface nearly plane to distinctly convex, strongly sulcate, the larger specimen a pallid, weathered, grayish color, the other near Sayal brown (R). Context as in the type but distinctly zoned, up to 7 millimeters thick behind. Pores as in the type, up to 8 millimeters long, in a single layer, blackish discolored on the lower surface.

Dissepiment and context hyphæ near olive lake, the former 2.2 to 6.0 μ, averaging 3.7 μ, the latter 2.2 to 6.0 μ, with an average of 4.0 μ. Spores from the crushed mount near deep olive-buff, with rather fine, distinct striæ, 5.2 to 6.7 by 7.5 to 10.4 μ, averaging 5.6 by 8.3 μ.

Discussion.—We are here dealing with a form variant of *Ganoderma applanatum* that it is impossible to segregate on any structural features. It appears characteristic, however, on account of its small size and the peculiar prolongation of some of the specimens into a short stem, and these are about the only descriptive characters by which it can be separated from its Brazilian congeners. While we do not ordinarily believe that form and size alone are worthy of even varietal rank, we are constrained to consider this a variety, which, however, should be interpreted to conform very closely to the type. Much confusion will result if we attempt to broaden the concept, since we might then be running into certain other Brazilian forms of the base species. Of the Brazilian specimens so far examined the *testaceum* forms have smaller spores, usually with finer striæ, but whether this distinction can be maintained after study of a much larger series remains for future investigations to determine.

In accordance with our present opinion we would call the fungus *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév.

We have seen the fungus only from Brazil, and it is probable that many of the specimens from other regions so determined are not strictly referable to it. The several determinations we have seen from the Philippines, although sometimes approaching the variety in form, have somewhat different spores. In our former paper on the *applanatum* group we established *Ganoderma applanatum* var. *tornatum* forma *macrospora.* While this is distinguishable from variety *tornatum* only by its larger *mastoporum* type of spore it has small, often young, forms, stipitate or sessile, usually of lighter weight that parallel similar young stipitate or sessile forms of variety *tornatum,* which are found closely associated with the larger, harder typical forms. It is reasonable then to refer those *testaceum*-like forms with *mastoporum*-like spores to variety *tornatum* forma *macrospora*, and this we prefer to do rather than to broaden the spore concept of *testaceum*.

In order better to convey our idea of the Philippine forms just mentioned we present illustrations and notes on three collections.

No. *50091* (Mount Banahao, Laguna Province, Luzon, *R. C. McGregor*, January 25, 1930) contains several nonlaccate, lightweight specimens (Plate 4, figs. 1 to 12), three of which have stipes, these stipitate forms ranging from 0.5 to 4.5 centimeters long and from 0.5 to 1 centimeter wide. A very young sterile specimen is nearly cylindrical, 2.5 centimeters long, 3 millimeters in diameter. Other specimens are small, contracted at the attachment, or with a slight to distinct umbo behind. The upper surface is somewhat lighter in color and less tuberculose than in the type of *testaceum* but is very close in these respects to *11059* just discussed. The lower surface varies from pallid to dark brown and offers nothing distinctive. While usually rather thick walled, in one specimen the pore walls become quite thin, the orifices being larger, but the number per millimeter remaining the same. The principal variations lie in the darker color of the context, which is near bay (R), and in the spores, which are indistinguishable from those of *mastoporum*.

The dissepiment hyphæ are near dark olive-buff, 2.3 to 5.3 μ, averaging 3.5 μ. The context hyphæ appear between old gold and buffy citrine, 2.3 to 6.0 μ, averaging 3.7 μ. Spores from the upper surface (Plate 12, fig. 10) are between deep olive-buff and dark olive-buff, 6.0 to 6.8 by 9.0 to 9.8 μ, with an average of 6.2 by 9.4 μ, with rather coarse, very distinct striæ. Young spores without striæ are found in crushed mounts intermixed with typical mature ones.

A collection loaned by the Buitenzorg Botanical Garden (*7114*, Batang Paloepoeh, west coast of Sumatra, *E. Jacobson*, July, 1924) closely matches the above Philippine material.

No. *50090* (Ube, Laguna Province, Luzon, *R. C. McGregor*, June 6, 1929) consists of two young sessile, applanate specimens (Plate 4, figs. 13 to 17), one of which is normally attached, the other attached at the center of the back. These are practically the same in form and external coloration as the thin applanate specimens of *11059* from Brazil, but differ in the context being darker and the spores being of the *mastoporum* type. They agree in all respects with an applanate specimen of *50091*.

No. *25107* (Mount Banahao, Laguna Province, Luzon, *H. S. Yates*, October, 1915)[9] was determined by Sydow as *Ganoderma testaceum*. The specimen consists of a thin spathulate sporophore, 6.3 centimeters long, about 5 centimeters wide, 1.3 centimeters thick at the base, contracted to a very small attachment and broadly umbonate behind. Upper surface plano-convex, avellaneous (R) to wood brown (R), zoned with somewhat darker bands, minutely puberulent, obscurely sulcate and slightly radiate ridged. Margin acute, sterile beneath for 1.5 millimeters. Context near auburn (R), firm corky, 6 millimeters thick at the umbo, tapering to 2 millimeters at the tip; with harder black streaks extending nearly to the margin. Lower surface pallid brownish, darker on bruising. Pores up to 7 millimeters long, near Verona brown (R) in longisection, about five to a millimeter, with medium dissepiments. Orifices circular to subcircular, with even, entire edges.

Context hyphæ near old gold, 2.2 to 7.5 μ, averaging 4.7 μ. Spores in crushed mount olive-buff to deep olive-buff, with rather coarse striæ, 4.5 to 6.7 by 7.8 to 9.3 μ, with an average of 5.9 by 8.6 μ.

SUMMARY

The paper offers additional data in support of the taxonomic position taken in our former article on the group. Several authentic specimens or types, together with a number of other variants, were loaned for study by the Kew Herbarium and the Paris Museum. Reports on these are presented.

Ganoderma australe (Fr.). A fragment of the pores of an authentic specimen from Fries in the Kew Herbarium, an African specimen from the same herbarium which is said to match it in spores, and an English specimen so named by Rea were compared. Since the authentic specimen lacked the crust and most of the context, definite conclusions could not be drawn as to its identity. The spores are approximately the same size as in *Ganoderma applanatum* var. *brownii* Murr., but are much paler and more finely striate than in that variety, which has the largest spores known in the *applanatum* group. As far as can be judged from the fragment submitted it differs little from the

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[9] Op. cit. 506.

African specimen, and may be the same species. If this be the case it cannot belong to the *applanatum* group, for the African material has a crust which is distinctly palisade in structure and is therefore excluded from the group.

The determination of Rea is something else, and the fungus may be *Ganoderma resinaceum* Boud. It is also close to *Ganoderma sessile* Murr. of the United States.

In view of the different interpretations given to *Ganoderma australe,* and the lack of satisfactory authentic material with which to compare, it will probably be best to drop the name.

Ganoderma tornatum (Pers.). An authentic Persoonian specimen, perhaps the type, from the Paris Museum, shows that our previous conception was correct. We refer it is a variety of *Ganoderma applanatum* (Pers.) Pat.

Ganoderma applanatum (Pers.) Pat. Two additional English specimens from the Kew Herbarium were examined. The applanate specimen is very close to North American material. The ungulate specimen approaches *Ganoderma applanatum* var. *brownii* but has much smaller spores.

Ganoderma leucophaeum (Mont.). A portion of Montagne's type confirms the opinion of most mycologists that it is nothing but a condition of *Ganoderma applanatum* with a pale crust. It agrees with much of the North American material and is not worthy of varietal segregation.

Ganoderma subtornatum Murr. An examination of the two Elmer collections from the Philippines cited by Murrill in the original description indicates that they are only forms of *Ganoderma mastoporum* (Lév.).

Ganoderma testaceum (Lév.). The type collection from the Paris Museum contains three specimens of *testaceum* and one specimen of *Fomes marmoratus* Berk. [*Fomes fasciatus* (Sw.)]. The fungus is at best a weak variety of *Ganoderma applanatum* and should be rather strictly interpreted to include only those forms in which the stipe develops as a horizontal prolongation of the pileus. While the spores are smaller than in other Brazilian material of *applanatum* examined, and thus help to segregate the variety in that region, nevertheless, they are quite similar to *applanatum* in other parts of the world. Philippine determinations are better referable to *Ganoderma applanatum* var. *tornatum* forma *macrospora* on account of the somewhat darker context and different type of spores.

ACKNOWLEDGMENT

We acknowledge with deep gratitude the services rendered by Rev. Henry C. Avery, S. J., Ph. D., professor of biology in the Ateneo de Manila, in translating from the Latin a considerable number of Persoonian and Friesian descriptions which have been used in our study.

ERRATA

Corrections to our previous paper, in the Philippine Journal of Science 45 (1931) 483-589.

Page 531. To the end of the first paragraph, records of *Ganoderma applanatum, add* Tawi Tawi Island, Sulu Archipelago, *H. S. Yates 35936.*

Page 535, in the fourth paragraph, *for* lines 2, 3, and 4 *read* province, Baguio, *M. S. Clemens 1039,* on *Pinus insularis, 1303* (B), Haight's Place, *F. Rivera* (supplemental type collection) *50085,* Pauai, *R. C. McGregor 8738;* Bontoc Subprovince, Mount Data, mossy forest, *M. S. Clemens 50084* (type collection), along high.

Page 543. In the twentieth line from the top, *50066* should be referred to *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. forma *macrospora* Humph.

Page 550. In the thirteenth line from the bottom, for *50016* read *50116.*

Page 551. In the last line of the first paragraph, for *50012* read *50112.*

ILLUSTRATIONS

PLATE 1

FIG. 1. *Ganoderma* sp. from the Kew Herbarium, probably from Africa, which has spores similar to those of an authentic specimen of *Polyporus australis* Fr. in the same herbarium. Upper surface of a segment from a large sporophore; × 0.68.

2. Lower surface of the specimen shown in fig. 1; × 0.68.
3. Section of the specimen shown in fig. 1; × 0.77.
4. *Ganoderma* sp. from England, determined by C. Rea as *Ganoderma australe* (Fr.). Upper surface of a section of a sporophore loaned by the Kew Herbarium; × 0.69.
5. Section of the specimen shown in fig. 4; × 0.69.
6. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Upper surface of a specimen loaned by the Paris Museum labelled "Polyporus tornatus v. B. applanatus, Rawak, Gaudichaud." This is apparently an authentic Persoonian specimen; × 0.68.
7. Lower surface of the specimen shown in fig. 6; × 0.68.
8. Label on the above Persoonian specimen; × 0.53.
9. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Upper surface of a specimen from the vicinity of Rio Janeiro, Brazil, loaned by the Paris Museum; × 0.68.
10. Lower surface of the specimen shown in fig. 9; × 0.68.
11. Section of the specimen shown in fig. 9; × 0.68.
12. *Ganoderma leucophæum* (Mont.) Pat. Upper surface of a specimen from Montagne's type collection. Loaned by the Paris Museum; × 0.69.
13. Lower surface of the specimen shown in fig. 12; × 0.69.
14. Section, parallel with the base, of the specimen shown in fig. 13; × 0.77.
15. Label on the above specimen of *Ganoderma leucophæum;* × 0.53.

PLATE 2

FIG. 1. *Ganoderma applanatum* (Pers.) Pat. Upper surface of a pale applanate form from England; × 0.54.

2. Lower surface of the specimen shown in fig. 1; × 0.54.
3. Section of specimen shown in fig. 1; × 0.57.
4. *Ganoderma applanatum* (Pers.) Pat. Front view of an ungulate form from England; × 0.57.
5. Section of the specimen shown in fig. 4; × 0.57.
6. *Ganoderma subtornatum* Murr. Upper surface of Elmer's *Philippine Plants 7213,* Palo, Leyte, P. I., cited in the original description. Loaned by the Kew Herbarium; × 0.54.
7. Lower surface of the specimen shown in fig. 6; × 0.54.
8. Section and rear view of the specimen shown in fig. 6; × 0.57.

PLATE 3

FIG. 1. *Ganoderma subtornatum* Murr. Upper surface of Elmer's *Philippine Plants 6943,* Mount Mariveles, Bataan Province, Luzon, P. I. Loaned by the Kew Herbarium; × 0.69.

2. Lower surface of the specimen shown in fig. 1; × 0.69.
3. Section of the specimen shown in fig. 1; × 0.77.
4. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Upper surface of one of the type specimens of *Polyporus testaceus* Lév., from Brazil. Loaned by the Paris Museum; × 0.69.
5. Lower surface of the specimen shown in fig. 4; × 0.69.
6. Upper surface of another specimen in the type collection of *Polyporus testaceus* Lév.; × 0.69.
7. Lower surface of the specimen shown in fig. 6; × 0.69.
8. Section of the specimen shown in fig. 6; × 0.70.
9. Upper surface of still another specimen in the type collection of *Polyporus testaceus* Lév.; × 0.77.
10. Lower surface of the specimen shown in fig. 9; × 0.69.
11. *Fomes marmoratus* Berk. Upper surface of a specimen included in the type collection of *Polyporus testaceus* Lév.; × 0.69.
12. Lower surface of the specimen shown in fig. 11; × 0.69.
13. Section of the specimen shown in fig. 11; × 0.70.
14. Label on the type collection of *Polyporus testaceus* Lév.; × 0.53.
15. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Upper surface of a sporophore, Humphrey herbarium *11059,* Rev. J. Rick, Brazil; × 0.67.
16. Section of the specimen shown in fig. 15; × 0.70.
17. Front view of another specimen of *11059*; × 0.67.
18. Section of another thin specimen of *11059;* × 0.67.
19. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Upper surface of another specimen from Rev. J. Rick, Brazil, Humphrey herbarium *11056;* × 0.67.
20. Section of the specimen shown in fig. 19; × 0.67.

PLATE 4

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS. FORMA MACROSPORA HUMPH.

FIGS. 1 to 11. Upper and lower surfaces of various specimens of Bureau of Science *50091,* Mount Banahao, Laguna Province, Luzon, P. I.; natural size.

FIG. 12. Section of one of the specimens of *50091;* × 1.03.

FIGS. 13 to 16. Upper and lower surfaces of two specimens of Bureau of Science *50090,* Ubi, Laguna Province, Luzon, P. I. Natural size.

FIG. 17. Section of the specimen shown in figs. 13 and 14; × 1.03.

PLATE 5

LONGISECTIONS OF CRUST, CONTEXT, AND PORES; × 4

FIG. 1. *Ganoderma australe* Fr. Fragment of an authentic specimen from Fries, loaned by the Kew Herbarium.

2. *Ganoderma leucophæum* (Mont.) Pat. Type specimen from the Paris Museum.

FIG. 3. *Ganoderma* sp. from England, determined by C. Rea as *Ganoderma australe* (Fr.).

4. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Type specimen of *Polyporus testaceus* Lév. from the Paris Museum.
5. *Ganoderma* sp. from the Kew Herbarium, probably from Africa, which has spores similar to the authentic specimen of Fries in the same herbarium.
6. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Authentic Persoonian specimen from the Paris Museum.

PLATE 6

FIG. 1. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 7213.* Longisection of context and pores; × 4.

2. Photomicrograph of radial section of the crust of specimen shown in fig. 1; × 121.
3. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 6943.* Longisection of context and pores; × 4.
4. Photomicrograph of radial section of the crust of specimen shown in fig. 3; × 121.
5. *Ganoderma* sp. from the Kew Herbarium, probably from Africa, which has spores similar to the authentic specimen of Fries in the same herbarium. Photomicrograph of radial section of the crust; × 121.
6. *Ganoderma* sp. from England, determined by C. Rea as *Ganoderma australe* (Fr.). Photomicrograph of radial section of the crust; × 121.

PLATE 7

PHOTOMICROGRAPHS OF RADIAL SECTIONS OF THE CRUST; × 121

FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Authentic Persoonian specimen from the Paris Museum.

2. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Brazilian specimen loaned by the Paris Museum.
3. *Ganoderma applanatum* (Pers.) Pat. Ungulate form from England.
4. *Ganoderma applanatum* (Pers.) Pat. Pale applanate form from England.
5. *Ganoderma leucophæum* (Mont.) Pat. Type collection from the Paris Museum.
6. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Type collection of *Polyporus testaceus* Lév. from the Paris Museum.

PLATE 8

PHOTOMICROGRAPHS OF CROSS SECTIONS OF THE PORES; × 121

FIG. 1. *Ganoderma australe* (Fr.). Authentic specimen from Fries in the Kew Herbarium.

2. *Ganoderma* sp. from the Kew Herbarium, probably from Africa, which has spores similar to the authentic specimen of Fries in the same herbarium.

FIG. 3. *Ganoderma* sp. from England, determined by C. Rea as *Ganoderma australe* (Fr.).

4. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Authentic Persoonian specimen from the Paris Museum.
5. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Brazilian specimen loaned by the Paris Museum.
6. *Ganoderma applanatum* (Pers.) Pat. Pale applanate form from England.
7. *Ganoderma applanatum* (Pers.) Pat. Ungulate form from England.
8. *Ganoderma leucophæum* (Mont.) Pat. Type collection from the Paris Museum.

PLATE 9

PHOTOMICROGRAPHS OF CROSS AND LONGISECTIONS OF PORES; × 121

FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Type collection of *Polyporus testaceus* Lév. from the Paris Museum.

2. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 7213.*
3. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 6943.*
4. *Ganoderma australe* (Fr.). Authentic Friesian specimen from the Kew Herbarium.
5. *Ganoderma* sp. from the Kew Herbarium, probably from Africa, which has spores similar to the authentic specimen of Fries in the same herbarium.
6. *Ganoderma* sp. from England, determined by C. Rea as *Ganoderma australe* (Fr.).
7. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Authentic Persoonian specimen from the Paris Museum.
8. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Brazilian specimen from the Paris Museum.

PLATE 10

PHOTOMICROGRAPHS OF LONGISECTIONS OF PORES; × 121

FIG. 1. *Ganoderma applanatum* (Pers.) Pat. Pale applanate form from England.

2. *Ganoderma applanatum* (Pers.) Pat. Ungulate form from England.
3. *Ganoderma leucophæum* (Mont.) Pat. Type collection from the Paris Museum.
4. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Type collection of *Polyporus testaceus* Lév. from the Paris Museum.
5. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 7213.*
6. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 6943.*

PLATE 11

PORE SURFACES; × 20

FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. Authentic Persoonian specimen from the Paris Museum.

2. *Ganoderma leucophæum* (Mont.) Pat. Type from the Paris Museum.

FIG. 3. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. Type collection of *Polyporus testaceus* Lév. from the Paris Museum.

4. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 6943.*
5. *Ganoderma subtornatum* Murr. Elmer's *Philippine Plants 7213.*

PLATE 12

SPORES; × 780

FIG. 1. *Ganoderma australe* (Fr.). From a crushed mount of the pores of the authentic Friesian specimen from the Kew Herbarium.

2. *Ganoderma* sp. from the Kew Herbarium, probably from Africa, which has spores quite similar to the authentic Friesian specimen. From the upper surface.
3. *Ganoderma* sp. from England, determined by C. Rea as *Ganoderma australe* (Fr.). From a crushed mount of the pores.
4. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. From a crushed mount of the pores of the authentic Persoonian specimen from the Paris Museum.
5. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. From the upper surface of the Brazilian specimen from the Paris Museum.
6. *Ganoderma applanatum* (Pers.) Pat. From the upper surface of the pale applanate form from England.
7. *Ganoderma applanatum* (Pers.) Pat. From the upper surface of the ungulate specimen from England.
8. *Ganoderma leucophæum* (Mont.) Pat. From a crushed mount of the pores of the type specimen from the Paris Museum.
9. *Ganoderma applanatum* (Pers.) Pat. var. *testaceum* Lév. From the upper surface of one of the type specimens of *Polyporus testaceus* Lév. from the Paris Museum.
10. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers. forma *macrospora* Humph. From the upper surface of *Bureau of Science 50091.*
11. *Ganoderma subtornatum* Murr. From a crushed mount of the pores of Elmer's *Philippine Plants 7213.*
12. *Ganoderma subtornatum* Murr. From a crushed mount of the pores of Elmer's *Philippine Plants 6943.*
13. *Ganoderma subtornatum* Murr. From the upper surface of Elmers' *Philippine Plants 6943.*

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Ganoderma applanatum (Pers.) Pat. Pale applanate form from England. Plate 2, figs. 1 to 3; Plate 7, fig. 4; Plate 8, fig. 6; Plate 10, fig. 1.

Ganoderma applanatum (Pers.) Pat. Ungulate form from England. Plate 2, figs. 4, 5; Plate 7, fig. 3; Plate 8, fig. 7; Plate 10, fig. 2; Plate 12, fig. 7.

Ganoderma sp., from Kew Herbarium, probably from Africa. Spores similar to those of an authentic specimen of *Polyporus australis.* Plate 1, figs. 1 to 3; Plate 5, fig. 5; Plate 6, fig. 5; Plate 8, fig. 2; Plate 9, fig. 5; Plate 12, fig. 2.

Ganoderma sp., from England, determined by Rea as *Ganoderma australe* Fr. Plate 1, figs. 4, 5; Plate 5, fig. 3; Plate 6. fig. 6; Plate 8, fig. 3; Plate 9, fig. 6; Plate 12, fig. 3.

Ganoderma australe (Fr.). Authentic Friesian specimen from Kew Herbarium. Plate 5, fig. 1; Plate 8, fig. 1; Plate 9, fig. 4; Plate 12, fig. 1.

Ganoderma applanatum (Pers.) Pat. var. *tornatum* Pers., from Brazil, loaned by the Paris Museum. Plate 1, figs. 9 to 11; Plate 7, fig. 2; Plate 8, fig. 5; Plate 9, fig. 8; Plate 12, fig. 5.

Ganoderma applanatum (Pers.) Pat. var. *tornatum* Pers. Authentic Persoonian specimen of *Polyporus tornatus* v. *B. applanatus.* Plate 1, figs. 6 and 7; Plate 5, fig. 6; Plate 7, fig. 1; Plate 8, fig. 4; Plate 9, fig. 7; Plate 11, fig. 1; Plate 12, fig. 4.

Ganoderma applanatum (Pers.) Pat. var. *tornatum* Pers. forma *macrospora* Humph. 50,090 (B. S.) Plate 4, figs. 13 to 16; 50,091 (B. S.) Plate 4, figs. 1 to 12; Plate 12, fig. 10.

Ganoderma leucophæum (Mont.) Pat. Montagnes type collection from Paris Museum. Plate 1, figs. 12 to 14; Plate 5, fig. 2; Plate 7, fig. 5; Plate 8, fig. 8; Plate 10, fig. 3; Plate 11, fig. 2; Plate 12, fig. 8.

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Elmer 7213. Plate 2, figs. 6 to 8; Plate 6, figs. 1 and 2; Plate 9, fig. 2; Plate 10, fig. 5; Plate 11, fig. 5; Plate 12, fig. 11.

Ganoderma applanatum (Pers.) Pat. var. *testaceum* Lév. Type specimens of *Polyporus testaceus* Lév. Plate 3, figs. 4 to 10; Plate 5, fig. 4; Plate 7, fig. 6; Plate 9, fig. 1; Plate 10, fig. 4; Plate 11, fig. 3; Plate 12, fig. 9.

11056 (*H*). Plate 3, figs. 19 and 20.

11059 (*H*). Plate 3, figs. 15 to 18.

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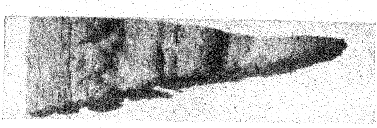
PLATES 1 to 4. Sporophores.
PLATE 5. Longisections of crusts, context, and pores.
PLATE 6, FIGS. 1 and 3. Longisections of context and pores.
PLATE 6. FIGS. 2, 4 to 6. Photomicrographs of structure of crust.
PLATE 7. Photomicrographs of structure of crust.
PLATES 8 to 10. Photomicrographs of crust and longisections of pores.
PLATE 11. Pores surfaces, enlarged.
PLATE 12. Photomicrographs of spores.



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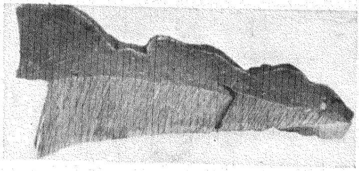

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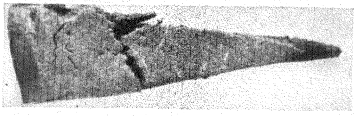

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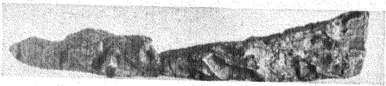

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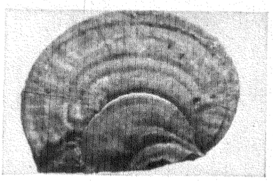

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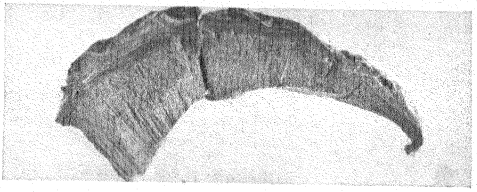

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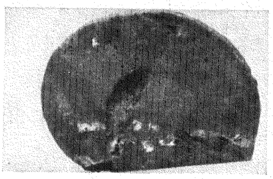

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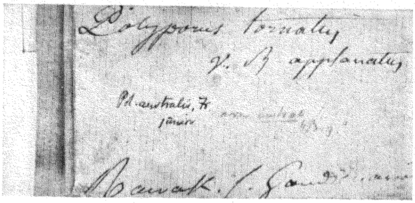

Polyporus tornatus
v. P. applanatus

Pl. australis, Fr.
junior

Banak. J. Gaud.

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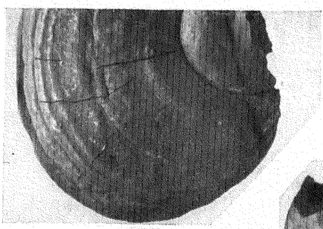

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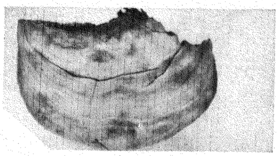

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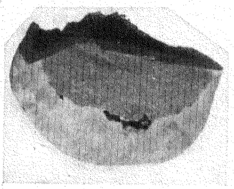

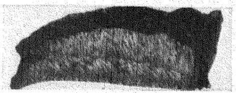

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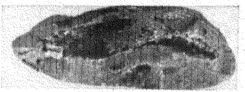

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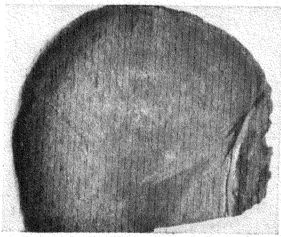

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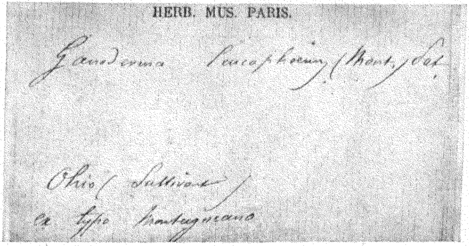

HERB. MUS. PARIS.

Ganoderma leucophaeum (Mont.) Pat.

Ohio (Sullivant)
ex typo Montagneano

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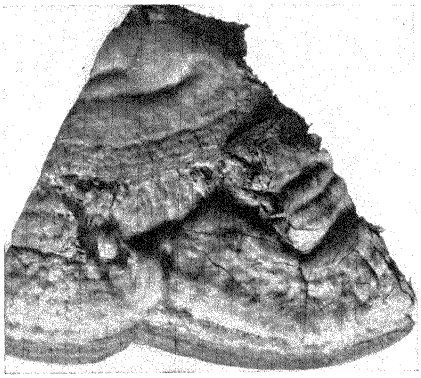
PLATE 1.



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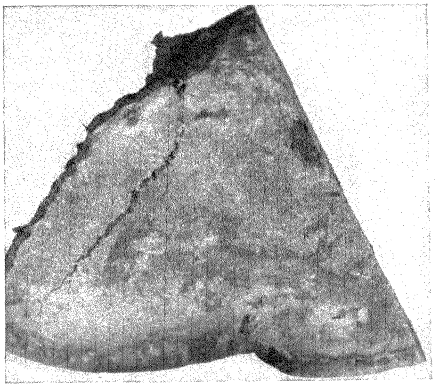

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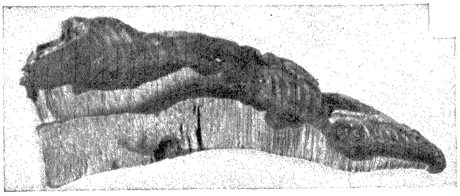

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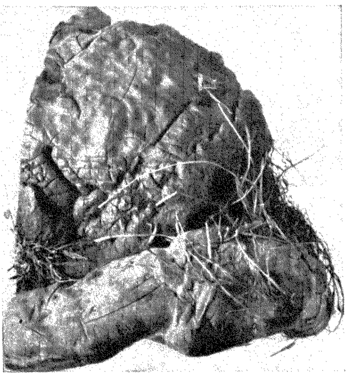

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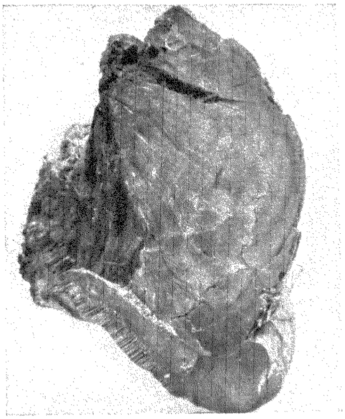

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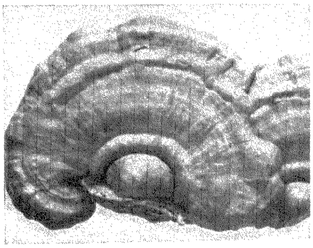

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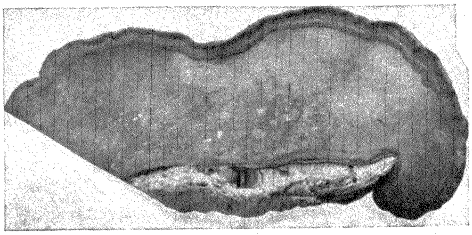

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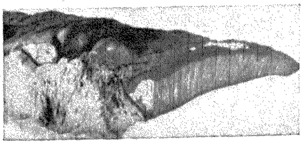

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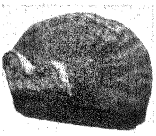
UNIV. OF MICH.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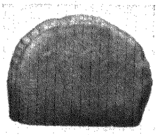
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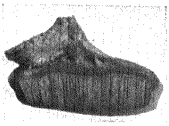
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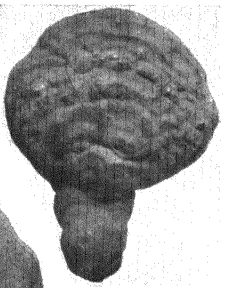
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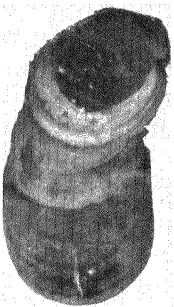
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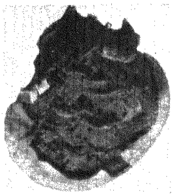
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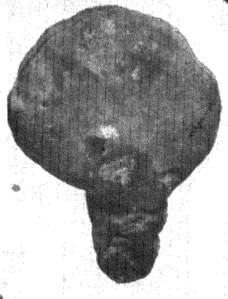
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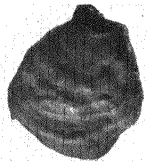
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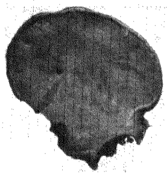
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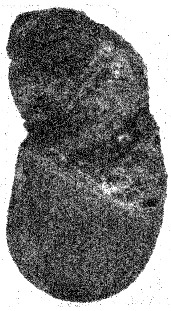
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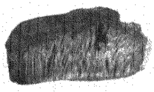
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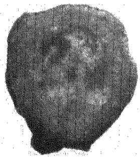
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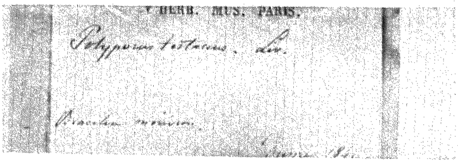
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Polyporus testaceus, Lév.

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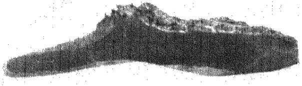
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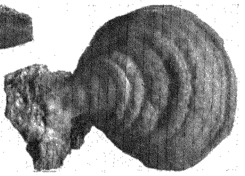
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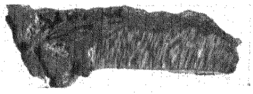
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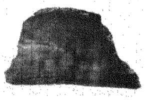
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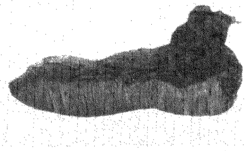
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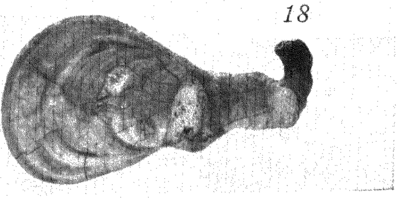
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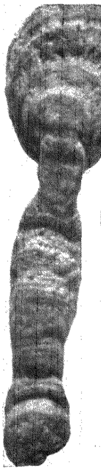
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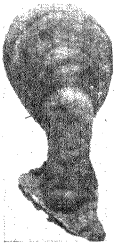
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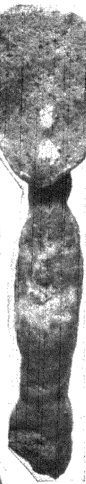
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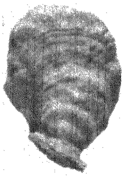
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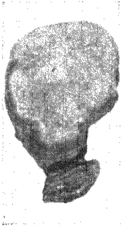
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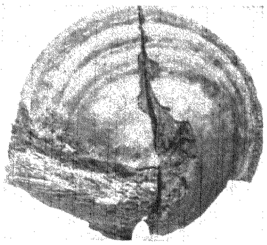
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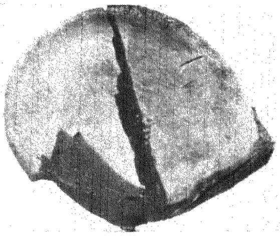
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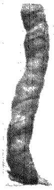
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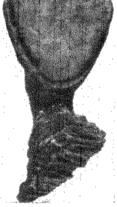
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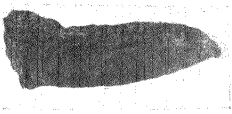
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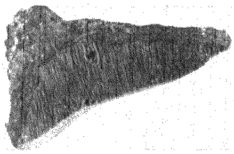
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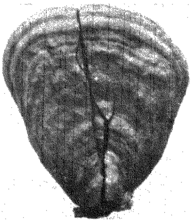
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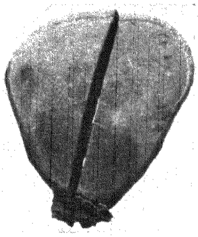
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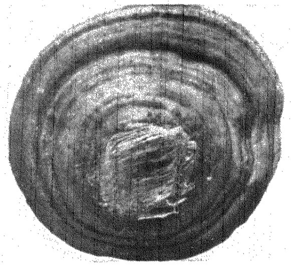
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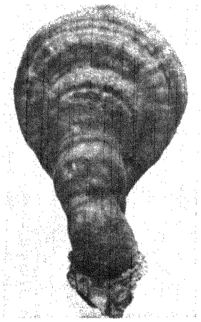
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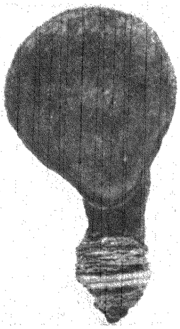
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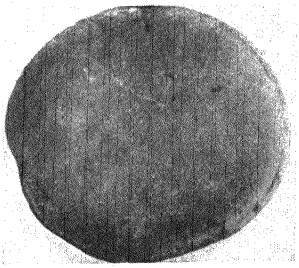
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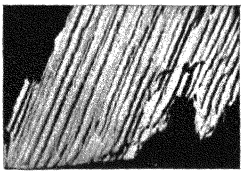

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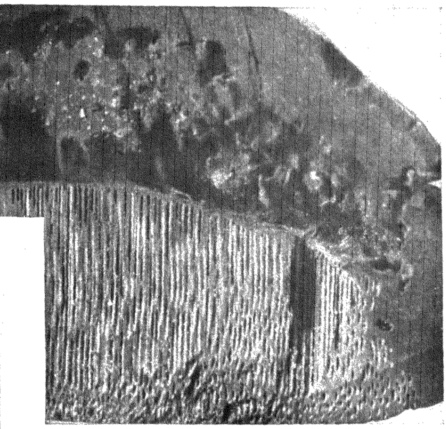

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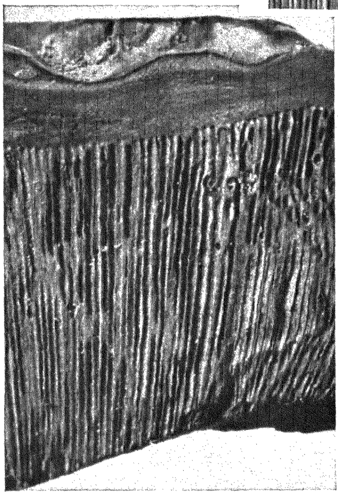

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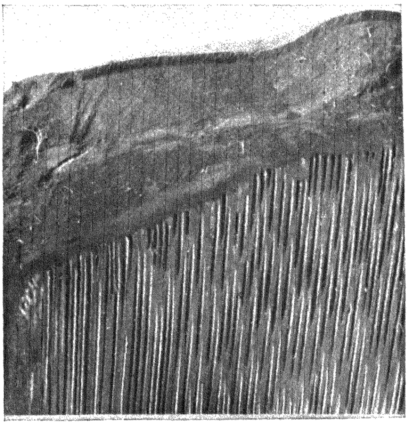

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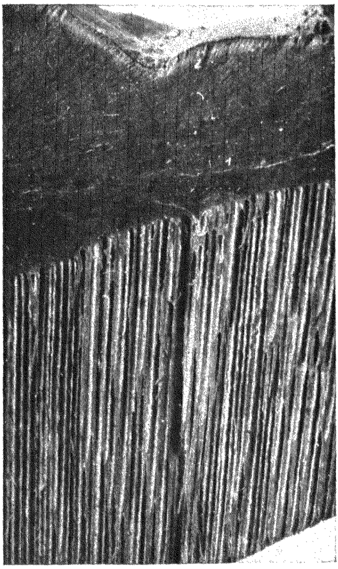

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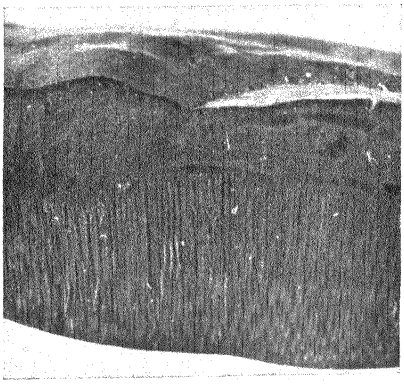

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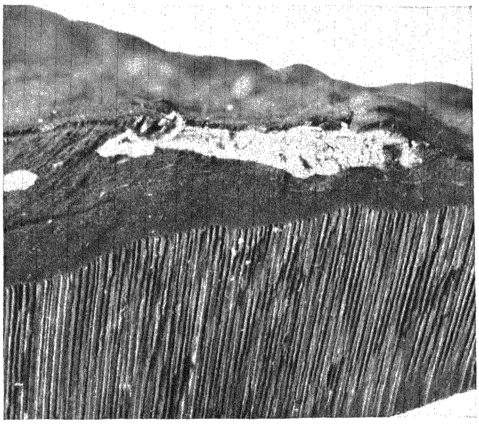

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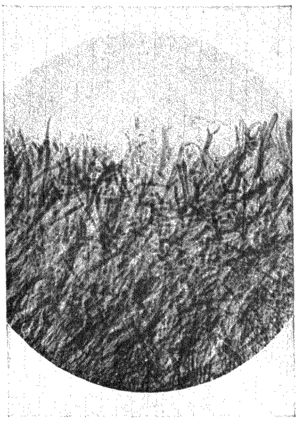

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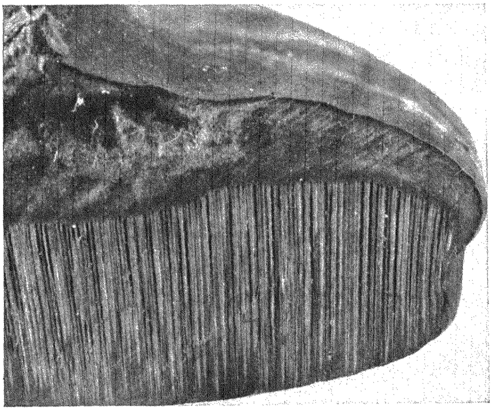

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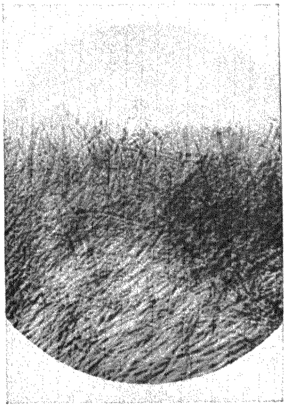

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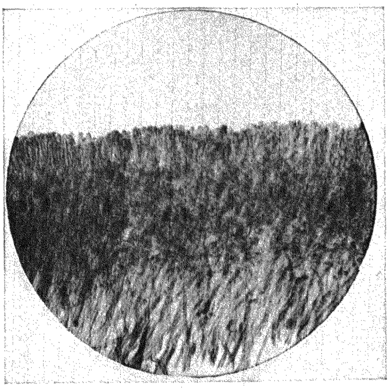

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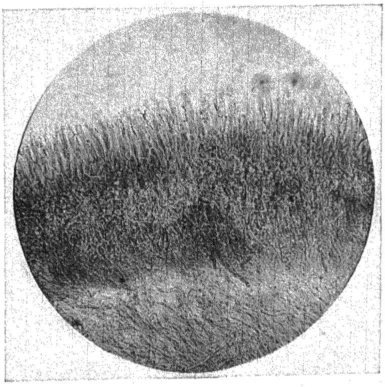

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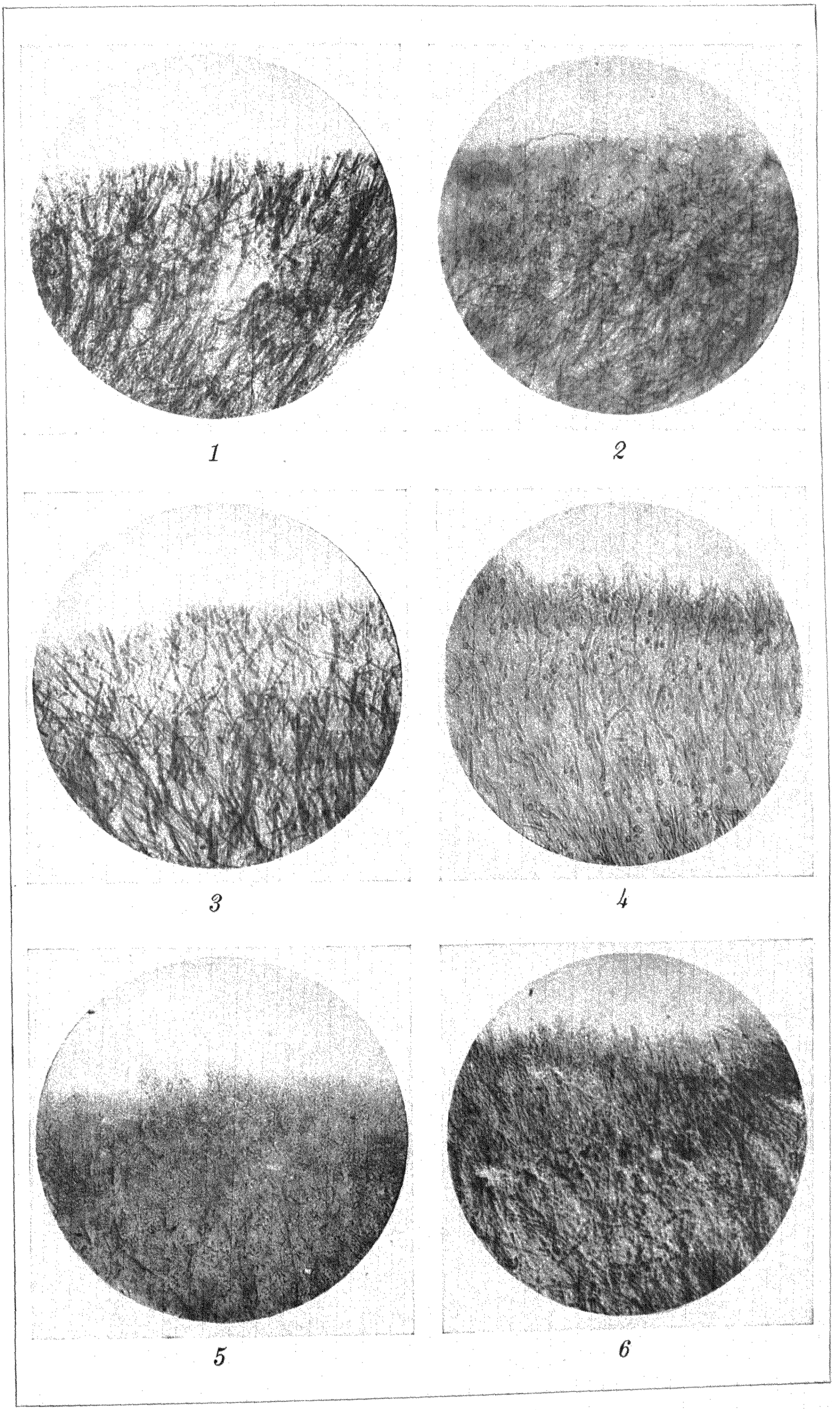

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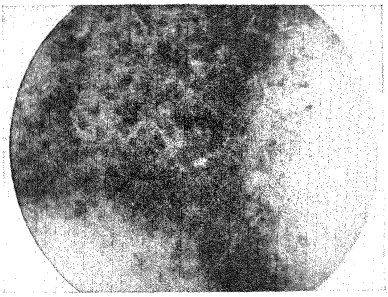

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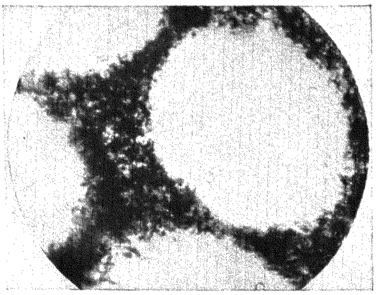

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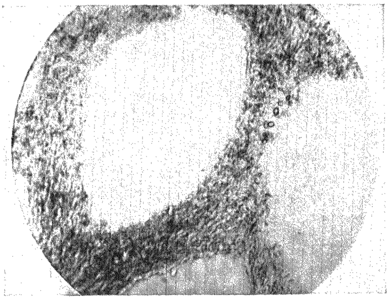

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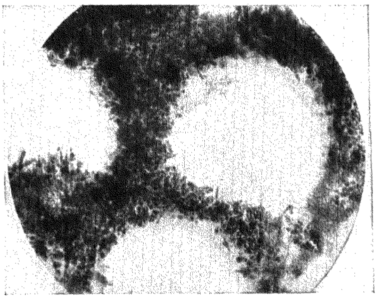

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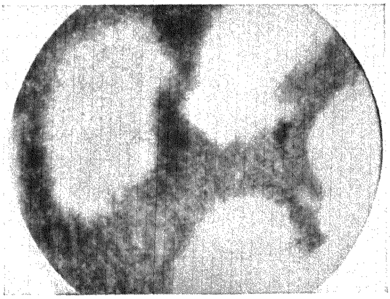

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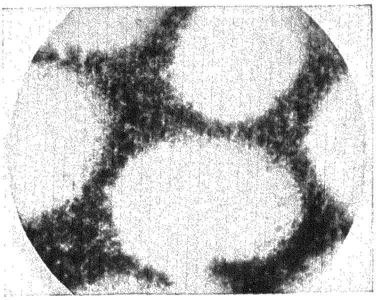

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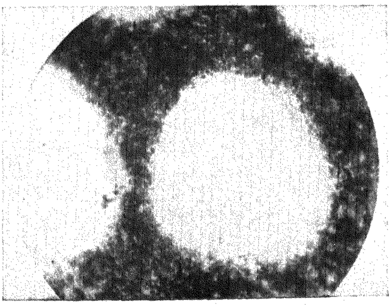

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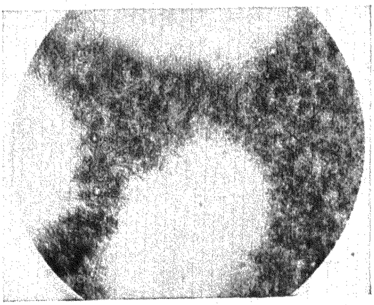

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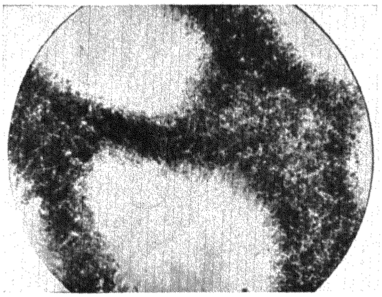

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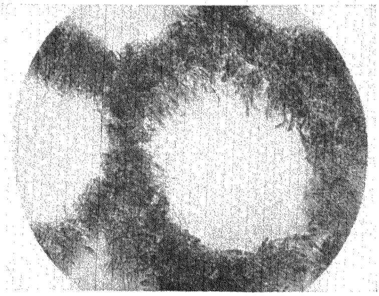

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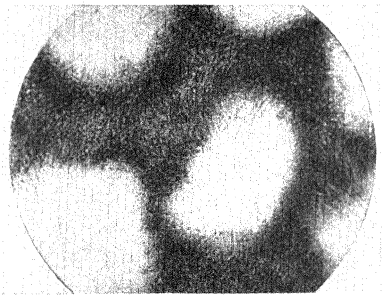

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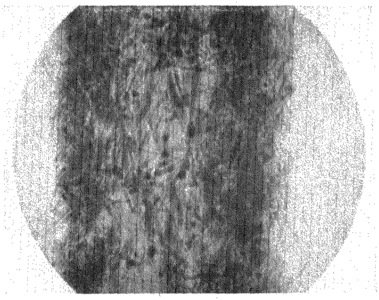

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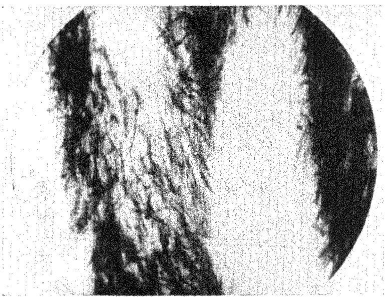

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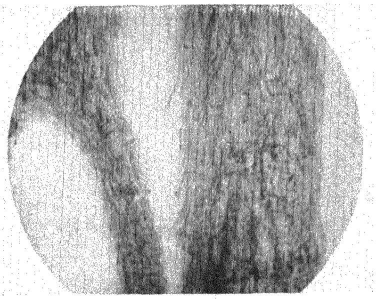

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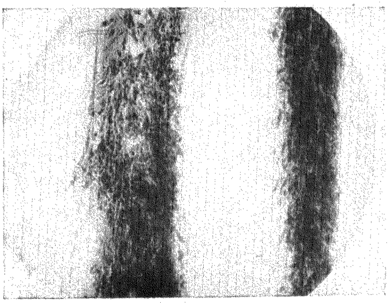

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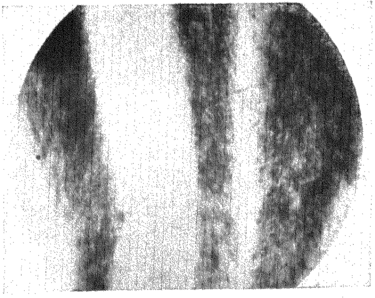

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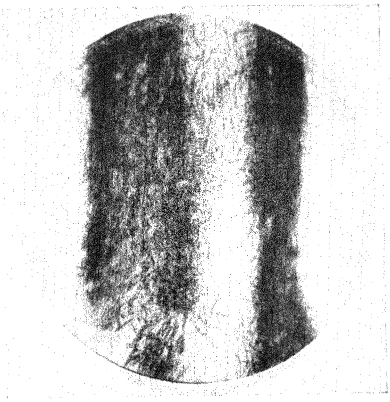

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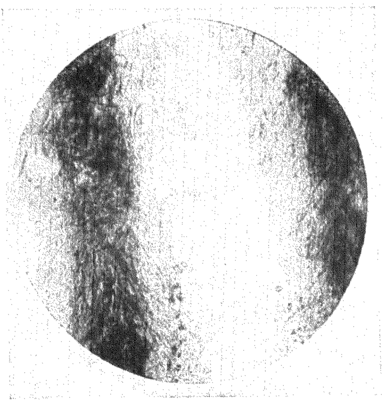

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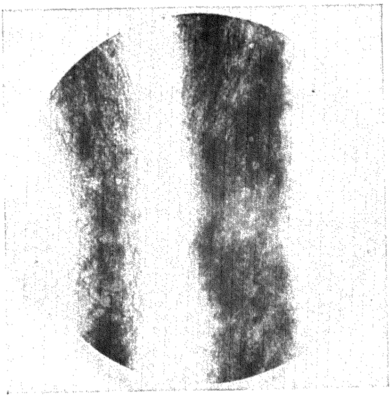

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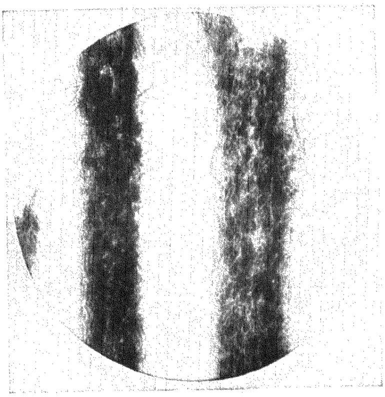

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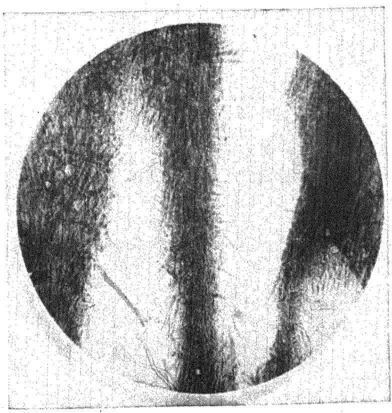

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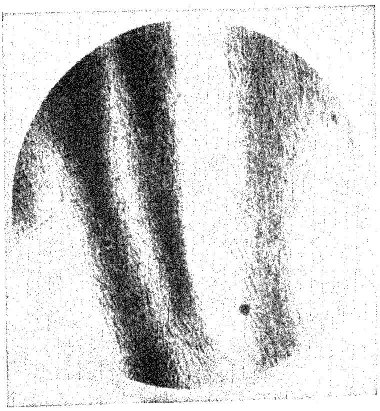

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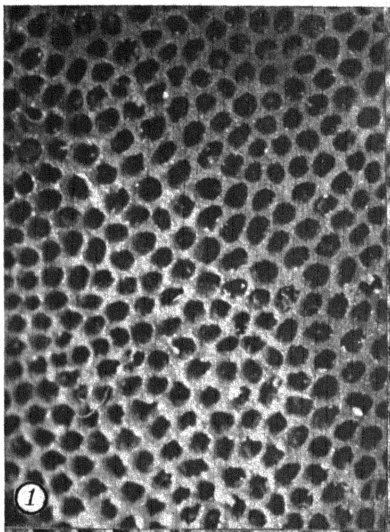

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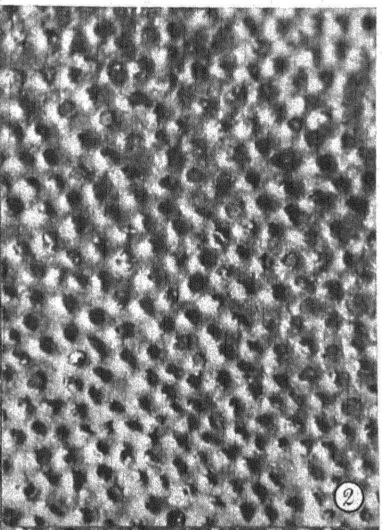

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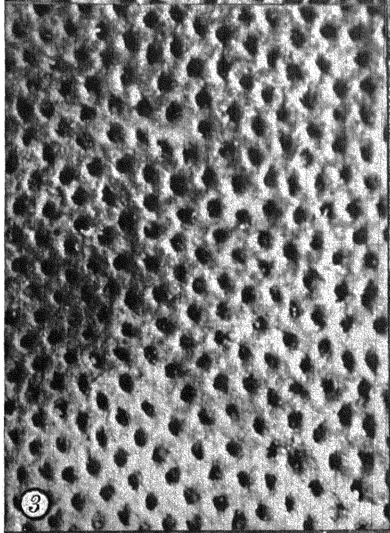

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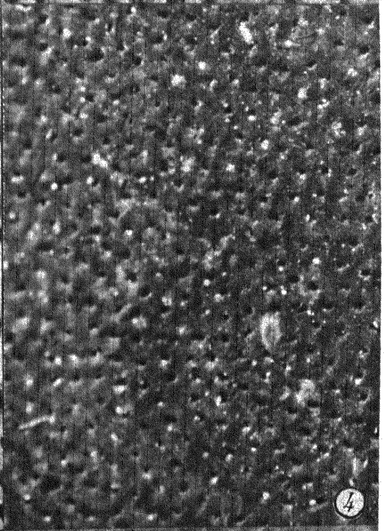

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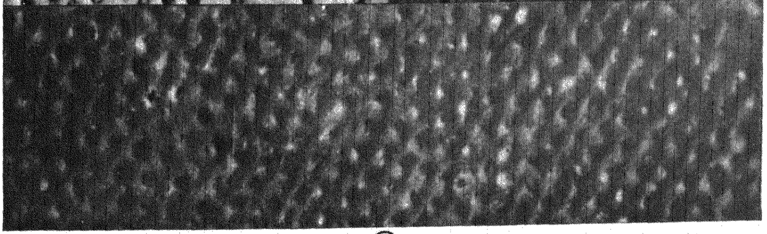

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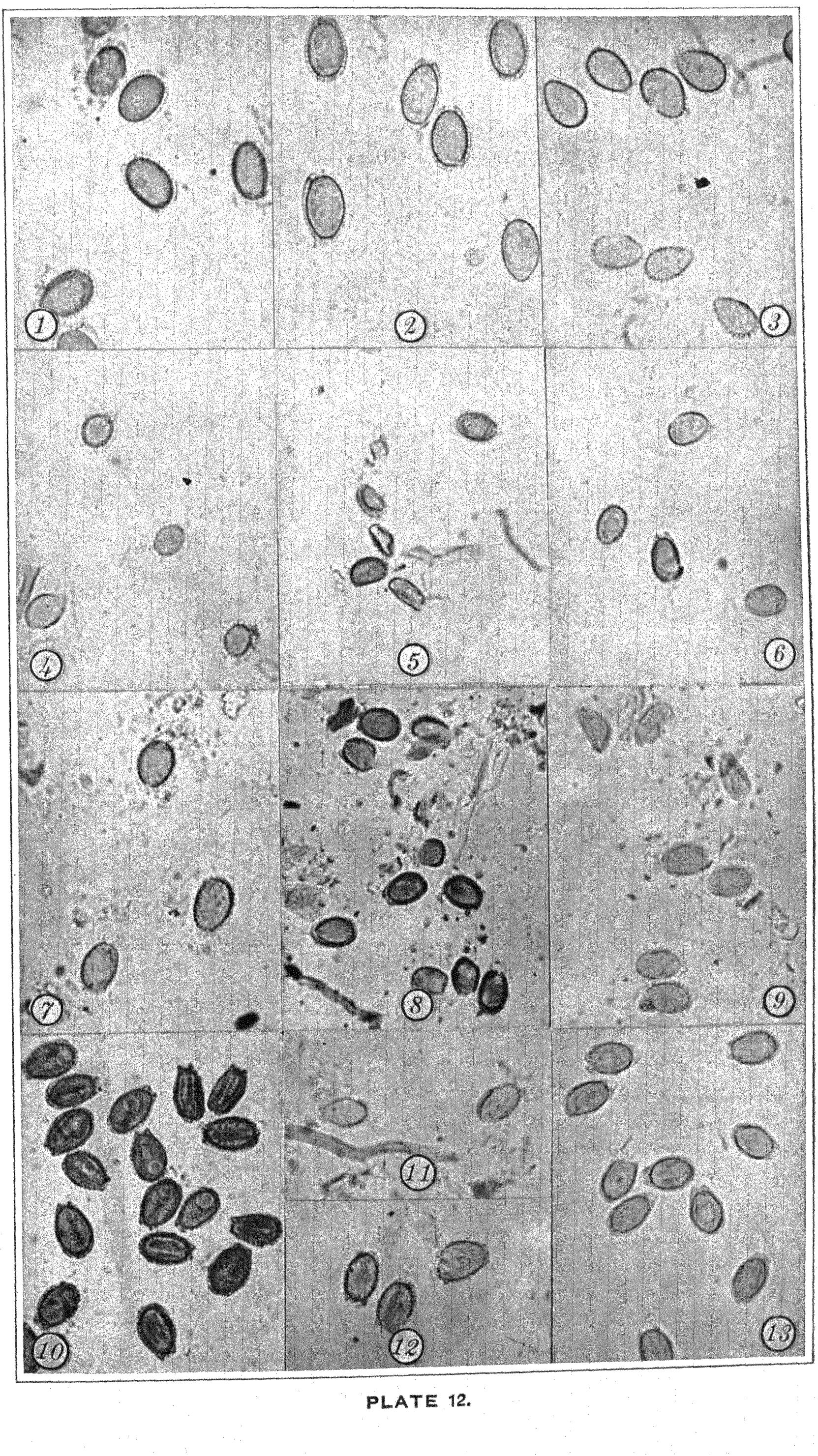

PLATE 12.

NEW OR NOTEWORTHY PHILIPPINE FUNGI, II

By JOSÉ MIGUEL MENDOZA

Associate Mycologist, Bureau of Science, Manila

TEN PLATES

INTRODUCTION

The Philippine flora is especially rich in the lower fungi and these offer very interesting material for mycological research. Although many collections have been named there remain in the Bureau of Science herbarium numerous specimens collected in different parts of the Archipelago which are undoubtedly new to science. It is the purpose of the writer to work over this collection as time permits and to report the results in a series of papers, of which this constitutes the second.[1] All the types have been deposited in the herbarium of the Bureau of Science, Manila.

FAMILY MICROTHYRIACEÆ SACCARDO AND SYDOW

ASTERINA XYLOSMAE sp. nov. Plate 1, figs. 1 to 5.

Colonia fungosa epiphylla, raro hypophylla, maculas orbiculatas et ad marginem irregulares, atras, non aequabiliter distributas et paene totam superficiem folii occupantes efformans; mycelio affluenti, fere a latere ramoso, ramis oppositis vel alternantibus; ex hyphis sucineo colore vel atro-fuscis, internodiis 21 ad 23 μ longis, 6 ad 7 μ latis; hyphopodiis 2-loculatis, numerosis, cylindraceis, juxta terminum rotundatis velraro leniter lobatis, alternatis vel generatim oppositis, ex hyphis a latere proclivibus, 11 ad 19 μ longis, 10 ad 11 μ latis; peritheciis paucis, globosis, 200 ad 361 μ diam.; stellatim dehiscentibus, contextu ex hyphis flavis vel subfuscis, quoad earum parietes, undulatis, 3 ad 4 μ latis, composito; ambitu non fimbriatis; ascis subglobosis vel generatim globosis, 8-sporiis, 47 ad 63 longis, 41 ad 57 μ latis; aparaphysatis; sporidiis immature hyalinis, mature fuscis, ellipsoideis, 1-septatis, medio constrictis, utrinque rotundatis; 16 ad 19 μ longis, 10 ad 11 μ latis.

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[1] The first was published in the Philip. Journ. Sci. 47 (1932) 289–294.

The fungus forms round black spots with irregular margin, 1 to 8 mm in diameter. It is mostly epiphyllous, scattered or almost covering the surface of the leaf. Mycelium thick, laterally branched; branches opposite or alternate, composed of amber to dark brown hyphæ, 21 to 23 μ long, 6 to 7 μ wide. Hyphopodia abundant, usually lateral, cylindric, rounded at the end or rarely slightly lobed, 2-celled, generally opposite, seldom alternate, 11 to 19 μ long, 10 to 11 μ wide. Perithecia few, globose, 200 to 361 μ in diameter; the walls splitting in a stellate manner and composed of sinuous, straw-colored to light brown hyphæ, 3 to 4 μ wide.

Asci usually globose, occasionally subglobose, 8-spored, 47 to 63 μ long, 41 to 57 μ wide; paraphyses none. Spores smooth, ellipsoid, constricted at the single septum, rounded at both ends, brown when mature, 16 to 19 μ long, 10 to 11 μ wide.

LUZON, Ilocos Norte Province, Bangui, *Bur. Sci. 27705, M. Ramos* (type), February, 1917, on leaves of *Xylosma.*

ASTERINA PLECTRONIAE sp. nov. Plate 2, figs. 1 to 5.

Colonia fungosa epiphylla, rarissime hypophylla, maculas irregulares, minus 1 mm diam. regionibus indefinitis, marginalibus atriis, et membranaceis circumdatas, subinde confluente et majorem partem folii occupantes efformans; mycelio parce distributo, raro ramoso et tunc ramis alternantibus, parietibus subasperis ex hyphis atrofuscis, 6 ad 7 μ latis, hyphopodiis brevibus, cylindraceis, numerosis, oppositis, 1-loculatis, acutis vel saltem ad terminos non rotundatis, a latere ab hyphis provenientibus, 11 ad 13 μ latis; peritheciis satis numerosis, globosis, limosis, 250 ad 291 μ diam., stellatim dehiscentibus, contextu ex hyphis fuscis, 5 ad 6 μ latis; ambitu valde fimbriato; ascis numerosis, globosis vel generatim ovatis; 8-sporiis, 60 ad 63 μ longis, 44 ad 60 μ latis; aparaphysatis; sporidiis immature hyalinis, mature fuscis, ellipsoideis, 1-septatis, medio constrictis, utrinque rotundatis, 27 ad 30 μ longis, 12 ad 16 μ latis.

The fungus produces irregular, usually epiphyllous, rarely hypophyllous, spots varying from less than 1 mm in diameter to confluent patches nearly covering the surface of the leaf. The mycelium is rather inclined to be sparse, seldom abundant, composed of dark brown hyphæ, 6 to 7 μ wide; branches few, alternate; walls roughened. Hyphopodia one-celled, numerous, opposite, short, cylindrical, inclined to be pointed, never rounded at the end, springing laterally from the mycelium, 11 to 13 μ long, 5 to 6 μ wide. Perithecia quite numerous, slimy, dark brown, globose, 250 to 291 μ in diameter; walls splitting in a stellate fashion, composed of brown hyphæ, 5 to 6 μ wide.

Asci abundant, generally ovate, seldom globose, 8-spored, 60 to 63 μ long, 44 to 60 μ wide; paraphyses none. Spores smooth, ellipsoid, 1-septate, constricted at the single septum, rounded at both ends, brown when mature, 27 to 30 μ long, 12 to 16 μ wide.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 33399 M. Ramos* (type), July 22, 1918, on leaves of *Plectronia cumingii* Elm.

This fungus somewhat resembles *Asterina xylosmae,* both having opposite hyphopodia and mycelial hyphæ of the same size. It also rather closely resembles *Asterina opposita* Syd.[2] in many characters, the hyphopodia of both being opposite, one-celled, and nearly the same in size. The hyphopodia of *A. opposita,* however, are rounded at the end, while those of *A. plectroniae* are more or less pointed, at least not rounded; they are more numerous in *A. opposita.* The mycelial hyphæ, the hyphæ that constitute the perithecia, and the spores, are almost identical in size in the two fungi. The principal difference lies in the perithecia of *A. plectroniae* being very much larger, darker in color, slimy, and very strongly fringed; the asci are also larger.

ASTERINA PLECTRONIAECOLA sp. nov. Plate 3, figs. 1 to 5.

Colonia fungosa amphigena, maculas irregulares atras efformans tenues, 2 mm—fere 8 mm diam., non aequabiliter distributas, quae vix discerni possunt per folii superficiem; mycelio exiguo, tenuiter ramoso, ex hyphis sucineo colore vel fuscis, crassis, 4.5 ad 6 μ latis, composito; hyphopodiis paucis, cylindraceis, 1-loculatis, ad apicem rotundatis vel rarissime simpliciter lobatis, irregulariter ordinatis, 10 ad 13 μ longis, 5 ad 6 μ latis; peritheciis paucis, rotundatis, limosis, atro-fuscis, 80 ad 160 μ diam; fimbriatis, stellatim dehiscentibus; contextu ex hyphis quoad parietes undatis, 2.5 ad 3 μ latis; ambitu parce fimbriatis; ascis paucis, globosis vel generatim ovato-globosis, 8-sporiis, 35 ad 41 μ longis, 28 ad 35 μ latis; aparaphysatis, sporidiis ellipsoideis, laevibus, oblongis, fuscis, intra ascum conglomeratis, 1-septatis, loculo superiore majore, 25 ad 29 μ longis, 10 ad 13 μ latis.

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[2] Leafl. Philip. Bot. 6 (1913) 1926.

This fungus forms irregular, thin, black, amphigenous spots varying from less than 2 mm to about 8 mm in diameter, not uniformly distributed on the surface of the leaf. Mycelium thin, rarely branched, the hyphæ amber to brown in color, thick-walled, 4.5 to 6 μ wide. Hyphopodia few, one-celled, cylindrical, the ends rounded or simply lobed, 10 to 13 μ long, 5 to 6 μ wide. Perithecia few, globose, slimy, dark brown, 80 to 160 μ in diameter with a fimbriate margin; walls splitting in a stellate manner, composed of sinuous hyphæ, 2.5 to 3 μ in diameter.

Asci few, ovate-globose, rarely globose, 35 to 41 μ long, 28 to 45 μ wide; paraphyses none. Spores oblong-elliptic, smooth, conglomerated within the ascus, constricted at the single septum, the superior cell the larger, rounded at both ends, brown, 25 to 29 μ long, 10 to 13 μ wide.

CATANDUANES, Calatagan and vicinity, *Bur. Sci. 30585, M. Ramos* (type), December 11, 1917, on leaves of *Plectronia gynochthodes.*

This fungus is quite similar to *Asterina densa* H. and P. Syd.[3] in many characteristics, but differs in its somewhat larger spores, asci, and smaller perithecia.

ASTERINA PHALERIAE sp. nov. Plate 4, figs. 1 to 5.

Colonia fungosa epiphylla, rarissime hypophylla, maculas minus 1 mm irregulares vel indefinites et quasi membranaceas, majorem partem superiorem folii occupantes efformans; mycelio satis infrequenti, perparce ramoso, ex hyphis flavis vel fuscis, 4.5 ad 6 μ latis composito; hyphopodiis sat frequentibus, cylindraceis, distincte lobatis, irregulariter ordinatis, 10 ad 12 μ longis, 6 ad 7 μ latis; peritheciis infrequentibus, rotundatis, 80 ad 120 μ diam.; stellatim dehiscentibus, contextu ad marginem flavo, atro-fusco ad partem centralem, ex hyphis quoad parietes undatis, 3 ad 4 μ latis; ambitu valde fimbriatis; ascis paucis, globato-ovatis vel generatim globosis, 8-sporiis, 30 ad 35 μ longis, 25 ad 31 μ latis, aparaphysatis; sporidiis ellipsoido-oblongis, 1-septatis, medio constrictis, loculo superiore majore, fuscis, 17 ad 22 μ longis, 9 ad 11 μ latis.

The fungus starts as marginate, irregular, epiphyllous, very seldom hypophyllous, spots less than 1 mm in diameter. It later becomes widely effused and forms a coating over the greater portion of the leaf surface. The mycelium is thin, composed of amber-colored to brown hyphæ, 4.5 to 6 μ wide; branches very few. Hyphopodia quite abundant, with no definite arrangement, one-celled, cylindric, distinctly lobed, 10 to 12 μ long, 6 to 7 μ wide. Perithecia few, globose, 80 to 121 μ in diameter, very strongly fringed at the periphery; walls splitting in a stellate manner, dark brown at the central portion, becoming amber-colored toward the margin; perithecial hyphæ sinuous, 3 to 4 μ wide.

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[3] Ann. Myc. 12 (1914) 557.

Asci few, globose, rarely globose-ovate, 8-spored, 30 to 35 μ long, 25 to 31 μ wide; paraphyses none. Spores brown, warted oblong-elliptic, constricted at the single septum, the superior cell being the larger, 17 to 22 μ long, 9 to 11 μ wide.

PANAY, Capiz Province, Libacao, *Bur. Sci. 35857 A. Martelino and G. Edaño* (type), June 13, 1919, on leaves *of Phaleria perrottetiana* (Decne.) F.-Vill.

There is a close resemblance between this fungus and *Asterina pipturi* Syd.,[4] the spores of both fungi being warted and ellipsoid, although those of *A. phaleriae* are more oblong. The asci and mycelial hyphæ of the two fungi are nearly similar in shape and size. The principal differences lie in the much larger perithecia and the more distinctly lobed and stouter hyphopodia of *A. phaleriae*.

ASTERINELLA CAPIZENSIS sp. nov. Plate 5, figs. 1 to 5.

Colonia fungosa stricte epiphylla, maculas irregulares, orbiculares de 1 mm ad 1 cm, confluentes, non aequabiliter sparsas per folii superficiem efformans; mycelio infrequenti, plus minusve irregulariter confluenti, ramoso, ex hyphis flavis vel fuscis, 3.5 ad 6 μ latis; desunt hyphopodia; perithecia frequentibus, globosis, 95 ad 200 μ diam., stellatim dehiscentibus; contextu ex hyphis cinereo-fuscis vel atro fuscis, septatis, 3 ad 5.5 μ latis composito; ascis paucis, ovato-globosis vel generatim globosis, 8-sporiis, 31 ad 39 μ longis, 31 ad 36 μ latis; aparaphysatis; sporidiis ellipsoideis, brevibus, utrinque rotundatis, laevibus, 1-septatis, medio constrictis, 19 ad 22 μ longis, 9 ad 10 μ latis.

The fungus is epiphyllous, producing round black spots with irregular margin, ranging from 1 mm to about 1 cm in diameter, these soon coalescing to form scattered irregular areas on the surface of the leaf. Mycelium thin, the branches fusing, composed of amber to brown hyphæ, 3.5 to 6 μ wide. Hyphopodia none. Perithecia abundant, globose, 95 to 200 μ in diameter; the walls easily splitting in a stellate manner and composed of radiating ashy brown to dark brown, septate hyphæ, 3 to 5.5 μ in diameter.

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[4] Ann. Myc. 14 (1916) 366.

Asci globose, rarely ovate-globose, 8-spored, 31 to 39 μ long, 31 to 38 μ wide; paraphyses none. Spores smooth, ellipsoid, short, rounded at both ends, constricted at the single septum, 19 to 22 μ long, 9 to 10 μ wide.

PANAY, Capiz Province, Capindan, San Juan Barrio, *Bur. Sci. 32109, M. Ramos and G. Edaño* (type), April 11, 1918, on leaves of *Leucosyke capitellata* (Poir.) Wedd.

This species very closely approaches *Asterinella ramuligera* Syd. The two species have the same shape of spores and asci. Both are aparaphysate and even in size of asci and spores there is but little difference. The main distinction lies in that *Asterinella phaleriae* is epiphyllous and has smooth spores, while *Asterinella ramuligera* is amphigenous, and has warted spores.

ASTEROMYXA SURIGAOENSIS sp. nov. Plate 6, figs. 1 to 7.

Colonia fungosa copiosa, stricte epiphylla, maculas efformans irregulares ad marginem, orbiculatas, de 1 mm (circiter) ad 1 cm diam., non aequabiliter ordinatas per folii superficiem; mycelio perexiguo, intertexto fulvo vel flavo colore; ex hyphis 6 μ latis, setosis; desunt hyphopodia; peritheciis frequentibus, orbiculatis, 86 ad 102 μ diam., perlucidis ita ut hymenia sint paene visibilia; contextu, qui facile amoveri potest, squamoso ex hyphis fulvis vel atrofuscis, 4 μ latis, composito; ambitu valde fimbriatis; ascis sat frequentis, 8-sporiis, globo-ovatis, 31 ad 44 μ longis, 19 ad 27 μ latis; aparaphysatis; sporidiis immaturis hyalinis, maturis fulvis vel flavis, ellipsoideis, oblongis, 1-septatis, utrinque rotundatis, medio constrictis, 14 ad 19 μ longis, 8 ad 9 μ latis; conidiis numerosis, brevibus, ellipsoideis, fulvis vel fuscis, 14 ad 18 μ longis, 9 ad 10 μ latis.

The fungus forms abundant round spots with irregular margin, strictly epiphyllous, varying from about 1 mm to 1 cm in diameter, unevenly distributed on the surface of the leaf. Mycilium sparse, intertwining, composed of straw-colored to light brown hyphæ, 6 μ wide; setose. Hyphopodia none, perithecia abundant, globose 86 to 102 μ in diameter, more or less transparent so that the hymenial layer inside is nearly visible; walls sloughing off to a considerable degree, composed of straw to dark brown hyphæ, 4 μ wide; periphery very strongly fringed.

Asci abundant, globose-ovate, 31 to 44 μ long, 19 to 27 μ wide, 8-spored; paraphyses none. Spores oblong-elliptic, rounded at both ends, constricted at the single septum, hyaline when young, amber-colored to brown when mature, 14 to 19 μ long, 8 to 9 μ wide. Conidia numerous, elliptical, short, amber to brown, 14 to 18 μ long, 9 to 10 μ wide.

MINDANAO, Surigao Province, Surigao, *Bur. Sci. 35901, M. Ramos and Pascasio* (type), May 18, 1919, on *unknown host* (Anonaceae).

This is the first species of *Asteromyxa* ever reported in the Philippines.

FAMILY CAPNODIACEÆ VON HÖHNEL

AITHALODERMA FICI sp. nov. Plate 7, figs. 1 to 3; Plate 8, figs. 1 to 6.

Colonia fungosa superficialis, amphigena, quamvis multum crassior per superiorem folii superficiem, aspera, atra, saepe totam superficiem obtegens, a substantia folii sine dificultate amovibilis at tunc speciem cutis membranacea habens; mycelio dematiaceo, abundanti crasso, irregulariter intertexto, saepius implexo, ex hyphis flavis vel fulvis, loculis brevibus et longis cylindraceis alternantibus, 5 ad 11 μ longis, 3.5 μ latis, composito; peritheciis numerosis, generatim sterilibus, rotundatis, 76 ad 99 μ diam., setosis sed setis rarissimis, solum circa ostiolum apparentibus et per ostioli regionem sparsis, brevibus, crassis, plus minusve angulatis et ad similitudinem puncti saggitarum accedentibus; ascis sat numerosis, cylindrico-oblongis, 8-sporiis, ad extremum rotundatis, 27 ad 35 μ longis, 11 ad 16 μ latis; aparaphysatis, sporidiis hyalinis, longis cylindraceis, fastigatis, sed ad apicem rotundatis, 3 ad 5-septatis sed generatim 5-septatis, 16 ad 19 μ longis, 3.5 ad 4 μ latis; pycnidiis numerosis, magnitudine valde variis, brevibus et crassis, longis et cylindraceis, flavis vel fuscis, 51 ad 143 μ longis, 12 ad 38 μ latis; pycnicsporiis numerosis, hyalinis, ovatis, minutissimis.

The fungus is superficial, rough, sooty, black, amphigenous, although much thicker on the upper surface of the leaf and often covering it; easily detached from the host like a thick sooty layer. Mycelium thick, dematioid, irregularly interweaving, often matlike; the hyphæ composed of short and long cylindrical cells, 5 to 11 μ long, 3.5 μ wide. Perithecia abundant, but mostly sterile, globose, 76 to 99 μ in diameter; setose; setæ very few, occurring only around the border of the ostiole or in its vicinity, short, more or less angular, resembling an arrowhead.

Asci quite abundant, oblong-cylindric, round at the apex, 27 to 35 μ long, 11 to 16 μ wide, 8-spored; paraphyses none. Spores hyaline, long, cylindric rounded at the distal end, tapering toward the other, 3 to 5-septate, usually the latter, 16 to 19 μ long, 3.5 to 4 μ wide. Pycnidia yellow to dark brown, quite abundant, highly variable in size, stout to very long cylindrical, 51 to 143 μ long, 12 to 38 μ wide. Pycniospores numerous, hyaline, oval, very small.

LUZON, Batangas Province, Looc, *Bur. Sci. 22674, M. Ramos and D. Deroy* (type), April 25, 1915, on leaves of *Ficus* sp.

Aithaloderma Syd. is a setose genus the type species of which is *A. clavatisporum* Syd.[5] *A. fici* differs from the type in having much narrower asci and very much smaller spores, with a much higher proportion of 5-septate ones. The pycnidia in *A. fici* are also much shorter and broader.

Aithaloderma setosum (Zimmerman) Boedijn,[6] a Javanese sooty mold, closely resembles the Philippine species in many respects but differs in having hairlike, septate setæ, while those of the species just described are stout and more or less sagittate.

CHAETOTHYRIUM MURIFORMIS sp. nov. Plate 9, figs. 1 to 3; Plate 10, figs. 1 to 5.

Colonia fungosa, superficialis, amphigena sed generatim epiphylla, paene totam superiorem folii superficiem obtegens, tenuem, atram cuticulam facile amovibilem efformans; mycelio dematiaceo, viride cinereo vel atro cinereo, implexo, ex cellulis ovatis cum loculis longis, cylindraceis, intertextis composito, (loculis brevibus 6 ad 14 μ longis, 6 ad 7 μ latis; loculis longis 8 ad 22 μ longis, 3 ad 6 μ latis); peritheciis numerosis, sine stilo, globatis, subviridibus vel atro fuscis, ostiolatis, magnitudine variis secundum perithecii aetatem *e. g.* 93 ad 213 μ diam., ostiolo sine margine definito, plus minusve pellucido; asci numerosis, cylindraceis octosporis, aparaphysatis, 58 ad 67 μ longis, 14 ad 20 μ latis; sporidiis muriformis, cum loculis irregularibus, 6- vel 11-septatis, aut per obliquum aut per longitudinem, generatim per longitudinum, dispositis, hyalinis vel roseis vel subflavis 26 ad 37 μ longis, 6.6 ad 19 μ latis; pycnidiis paucis, fulvis, plus minusve ovatis et ad extremum dilatis, ostiolatis, ostiolo ex loculis longis gracilibusque composito, 46 ad 60 μ longis, 26 ad 31 μ latis; pycniosporiis valde numerosis, ovatis, hyalinis, minutissimis.

The fungus produces a thin, sooty black, surface film easily detached from the host, amphigenous, although thicker on the upper surface and often almost covering it. Mycelium dematioid, forming a matlike weft composed mainly of ovoid cells interwoven with long cylindrical ones; short cells 6 to 14 μ long,

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[5] Ann. Myc. (1913) 257–258.

[6] Bull. Jard. Bot. Buitenzorg Sér. III 9 (1931) 227–228.

6 to 7 µ wide, long cells 8 to 22 µ long, 3 to 6 µ wide, pale olive-gray to deep grayish in color. Perithecia abundant, not stalked, globular, greenish gray to dark brown, the smallest 93 µ, the largest 213 µ in diameter; ostiole with no definite border, more or less transparent.

Asci numerous, cylindrical, rounded at the apex, 58 to 67 µ long, 14 to 20 µ wide, 8-spored; paraphyses none. Spores muriform with cells dissimilar in size, 6- to 11-septate, hyaline to rose, or approaching pale amber in color, 26 to 37 µ long, 6.6 to 19 µ wide. Pycnidia few, amber-colored, nearly pear-shaped, enlarged at the distal end, 48 to 60 µ long, 26 to 31 µ wide; with an ostiole composed of long, slender cells. Pycniospores very numerous, oval, hyaline, very small.

LUZON, Laguna Province, Los Baños, *Bur. Sci. 65001, J. M. Mendoza and E. Roldan* (type), October 20, 1931, on leaves of *Codiaeum variegatum* (Linn.) Blume.

Petrak[7] after careful study of certain of the Chaetothyriæ reached the conclusion that the genera *Limacinia, Treubiomyces,* and *Paeosaccardinula* should be fused with the genus *Chaetothyrium.*

After a study of *Chaetothyrium javanicum* (Zimm.) Boedijn[8] reached essentially the same conclusion as Petrak but suggested that the generic limits of *Chaetothyrium* should be somewhat extended to properly include the other three. In his studies of the sooty molds the writer[9] has experienced many difficulties among which may be mentioned the frequency with which they intermingle with other fungi, thus rendering it difficult to determine which of the elements belong to the one and which to the other organism. With the species just described the writer found an *Antennellina* associated.

The writer has compared *Chaetothyrium muriformis* with the descriptions of species published under *Phaeosaccardinula, Limacinia, Limacinula, Treubiomyces,* and *Chaetothyrium* and is convinced that it is a well-marked species.

ACKNOWLEDGMENTS

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[7] Ann. Myc. 27 (1929) 380–381.

[8] Bull. Jard. Bot. Buitenzorg. Sér. III 9 (1931) 227–228.

[9] Stevens, F. L., Hawaiian Fungi, Bernice P. Bishop Museum Bull. 19: 52–63; Ann. Myc. 28 (1930) 365–366.

and assisting in the preparation of the manuscript; of Rev. Henry C. Avery, S.J., Ph.D., of the Ateneo de Manila, in translating the English descriptions into Latin; of Dr. G. O. Ocfemia, in charge of the herbarium of the College of Agriculture, University of the Philippines, in loaning the writer specimens of the family Microthyriaceæ and Capnodiaceæ for study and comparisons; and of the Director of the Botanical Garden, Buitenzorg, Java, in loaning specimens of the family Microthyriaceæ to the Bureau of Science for the writer's studies.

ILLUSTRATIONS

PLATE 1. ASTERINA XYLOSMAE SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface, showing perithecia; × 20.
2. Portion of perithecium, with mycelium; × 1431.
3. Ascus, with eight ascospores; × 1431.
4. Two constricted ascospores; × 1431.
5. Mycelium with opposite, 2-celled hyphopodia; × 1431.

PLATE 2. ASTERINA PLECTRONIAE SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface, showing perithecia; × 20.
2. Portion of perithecium, with mycelium; × 1431.
3. Mycelium, with opposite, 1-celled, rough-walled hyphopodia; × 1431.
4. Ascus, with ascospores; × 1431.
5. Ascus, with ascospores, another type; × 1431.
6. Two 2-celled ascospores.

PLATE 3. ASTERINA PLECTRONIAECOLA SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface; × 20.
2. Portion of a perithecium, showing characteristics of perithecial hyphæ; × 1431.
3. Mycelium, with one-celled, lobate hyphopodia; × 1431.
4. Ascus, with ascospores; × 1431.
5. Two warted ascospores; × 1431.

PLATE 4. ASTERINA PHALERIAE SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface; × 20.
2. Portion of a perithecium; × 1431.
3. Mycelium, with one-celled hyphopodia; × 1431.
4. Ascus, with ascospores; × 1431.
5. Three constricted two-celled ascospores; × 1431.

PLATE 5. ASTERINELLA CAPIZENSIS SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface; × 20.
2. Portion of a perithecium; × 1431.
3. Mycelium, without hyphopodia; × 1431.
4. Ascus, with ascospores; × 1431.
5. Three constricted two-celled spores; × 1431.

PLATE 6. ASTEROMYXA SURIGAOENSIS SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface, showing numerous perithecia; × 20.
2. Portion of a perithecium; × 1431.
3. Mycelium, without hyphopodia; × 1431.
4. Ascus, with ascospores; × 1431.
5. Three constricted two-celled ascospores; × 1431.
6. A seta arising from the mycelium; × 1431.
7. Three conidia; × 1431.

PLATE 7. AITHALODERMA FICI SP. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface; × 20.
2. Upper surface of a leaf entirely covered by a sooty mycelial growth.
3. Lower surface of a leaf with several fungous colonies.

PLATE 8. AITHALODERMA FICI SP. NOV.

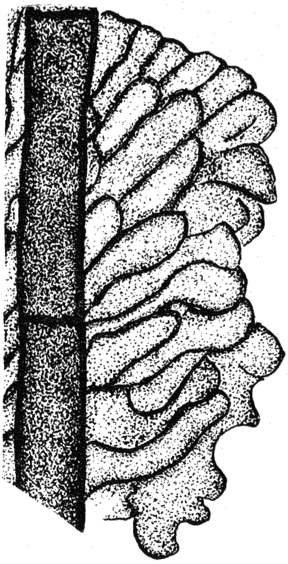
FIG. 1. Perithecium, showing setæ; × 254.
2. Photomicrograph of a perithecium, showing asci and the many-celled ascospores inside.
3. Ascus, with eight ascospores; × 1431.
4. Two ascospores; × 1431.
5. Mycelium; × 1431.
6. A pycnidium arising from the mycelium; × 1431.

PLATE 9. CHAETOTHYRIUM MURIFORMIS SP. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia; × 20.
2. Lower surface of a leaf, free of fungous growth.
3. Upper surface of a leaf, entirely covered by the fungus.

PLATE 10. CHAETOTHYRIUM MURIFORMIS SP. NOV.

FIG. 1. Portion of a perithecium; × 1431.
2. A young ascus; × 1431.
3. A mature ascus with eight ascospores; × 1431.
4. Four ascospores, showing different types; × 1431.
5. Mycelium; × 1431.
6. A pycnidium with numerous pycnidia; × 1431.



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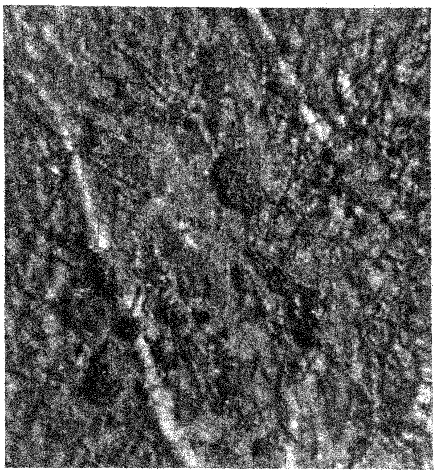

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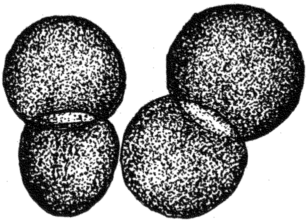

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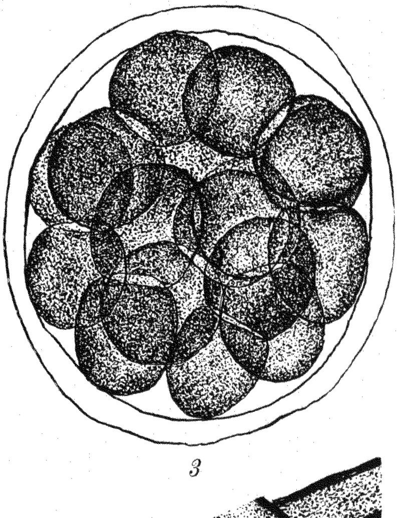

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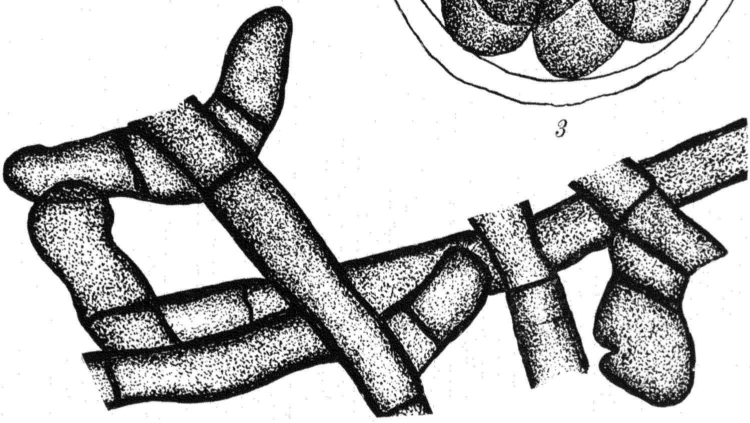

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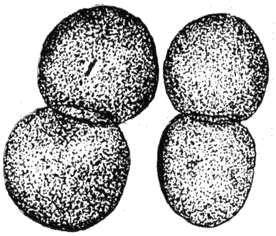

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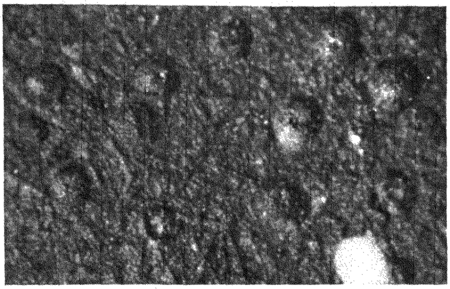

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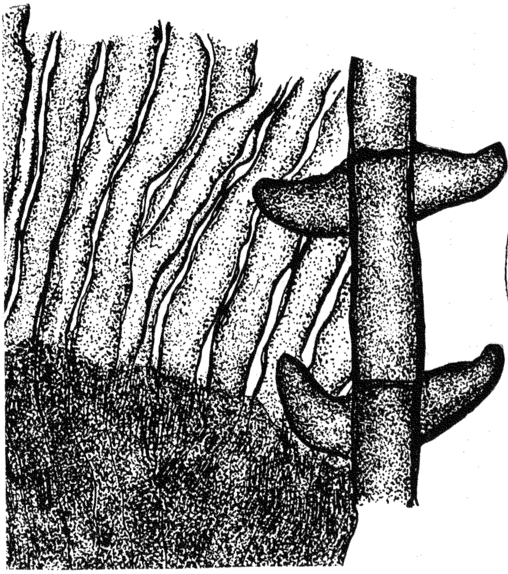

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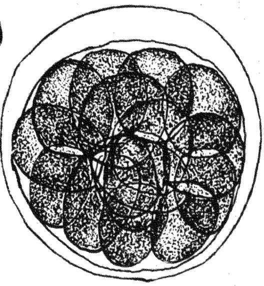

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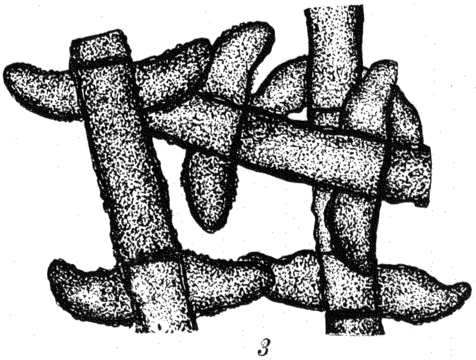

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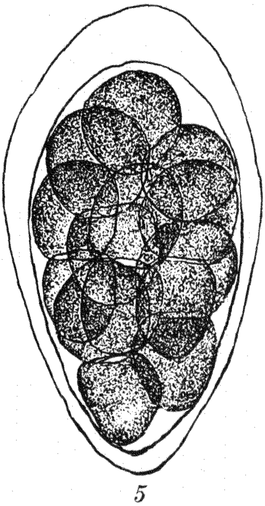

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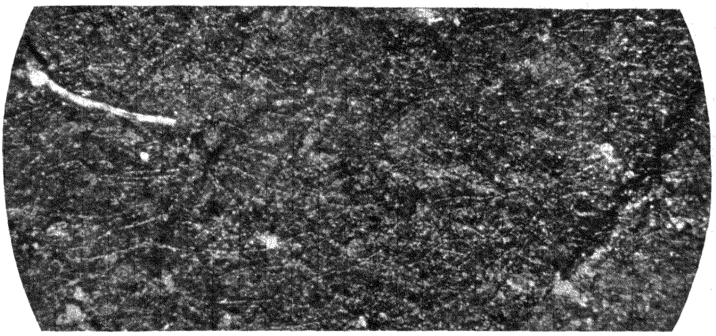

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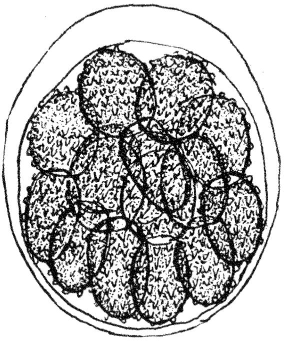

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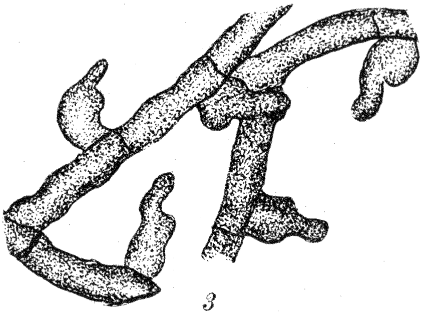

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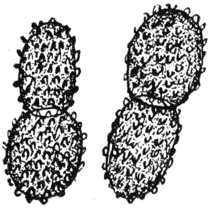

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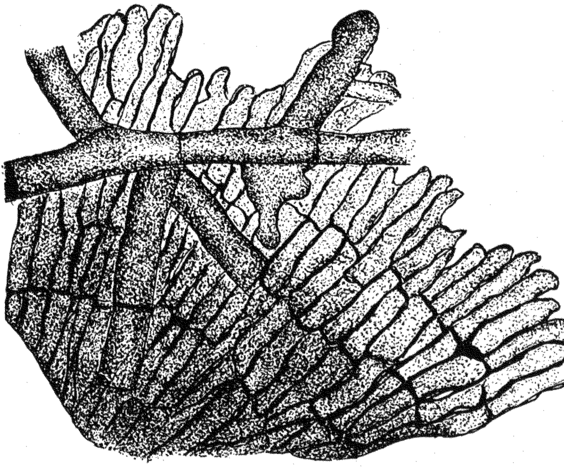

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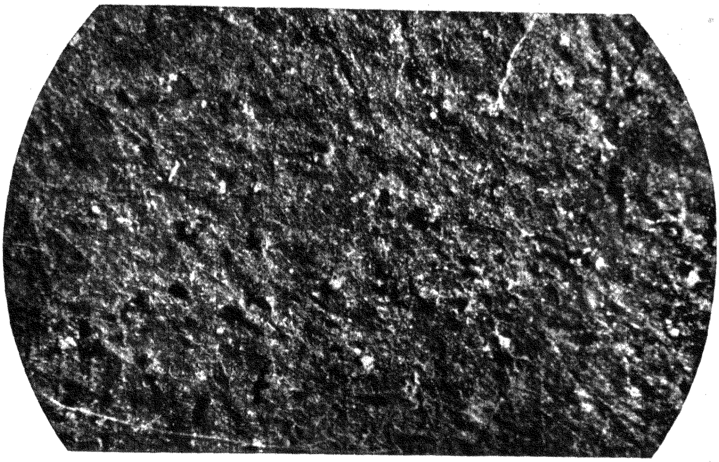

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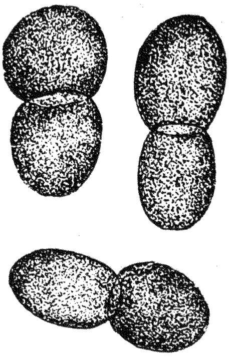

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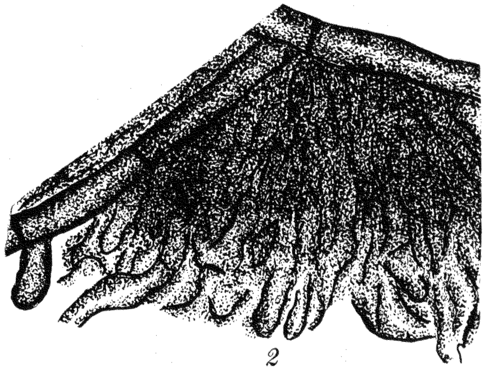

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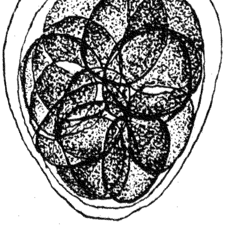

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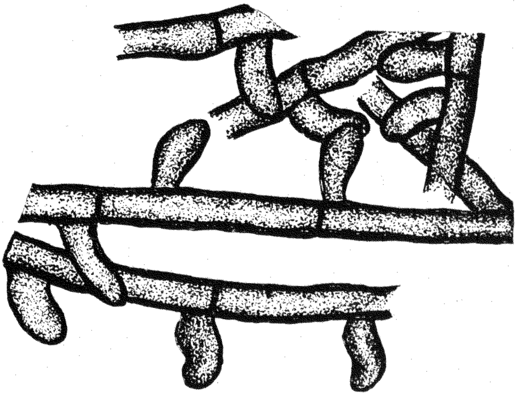

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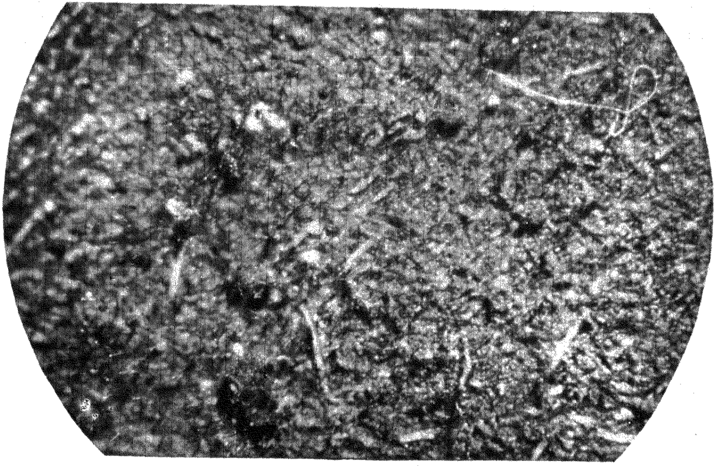

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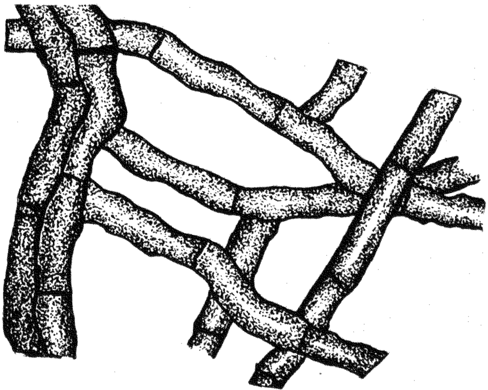

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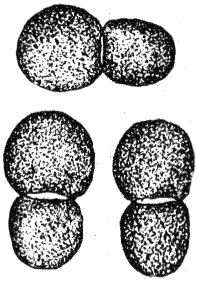

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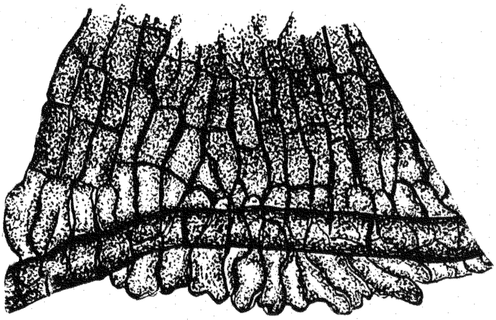

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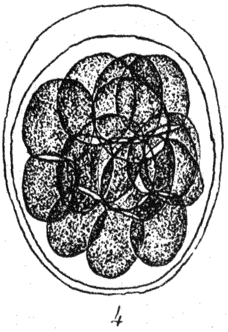

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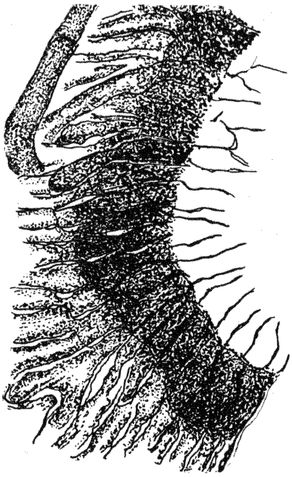
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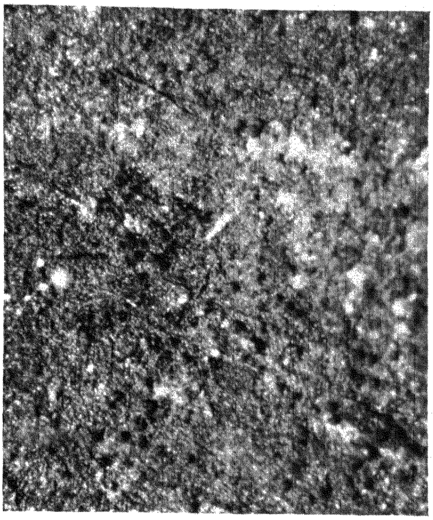
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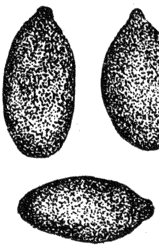
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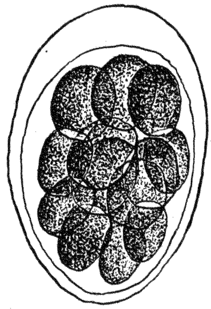
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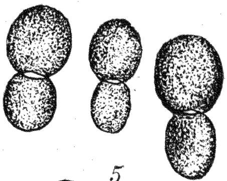
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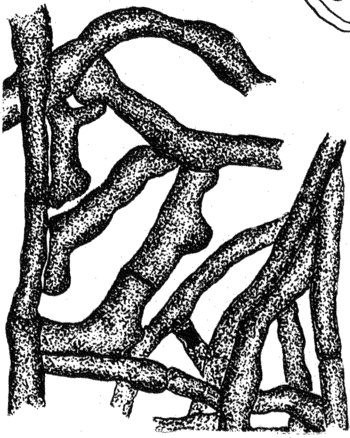
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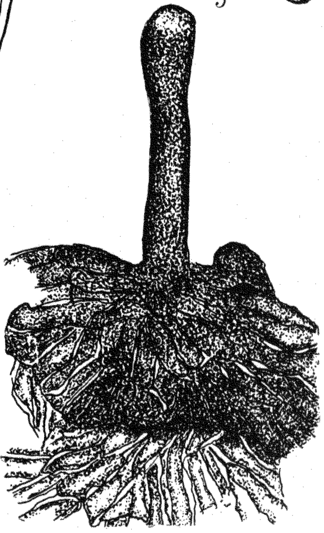
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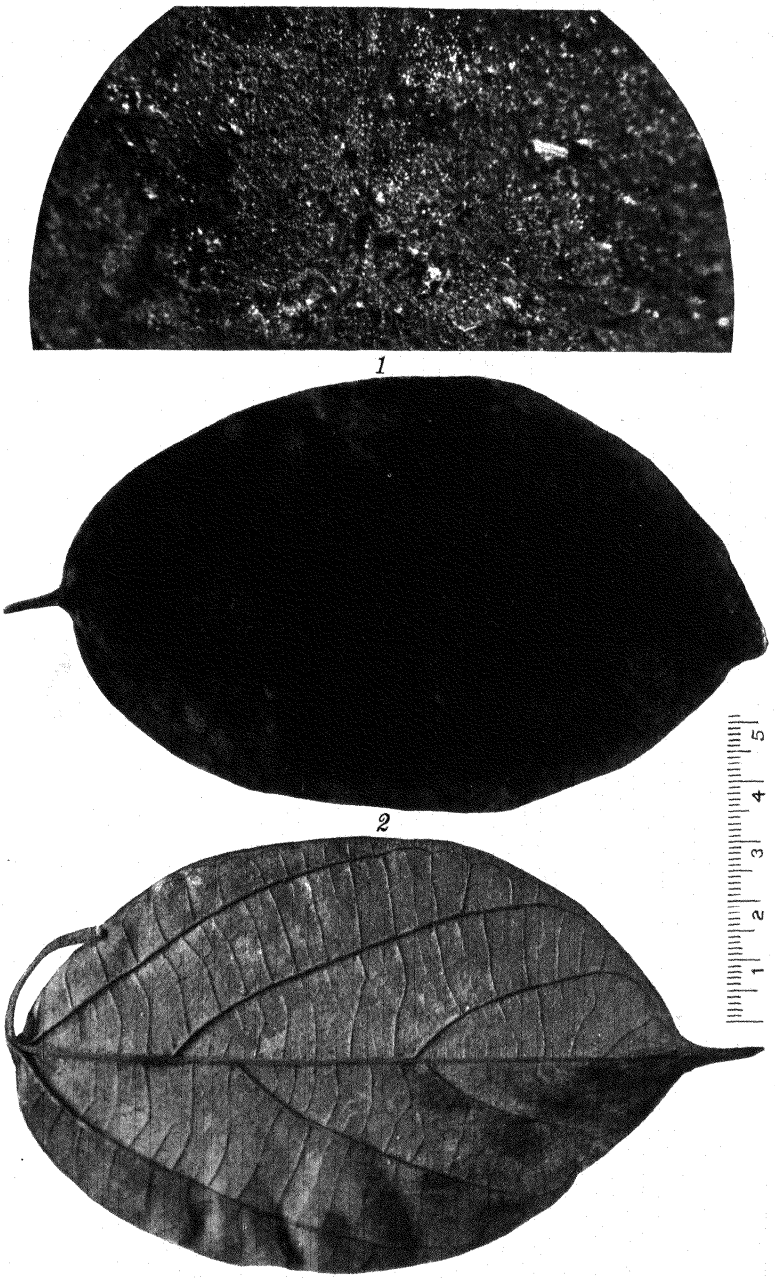

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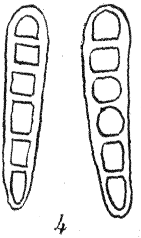

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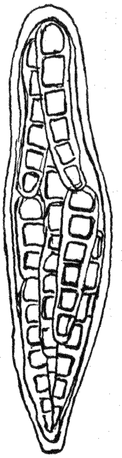

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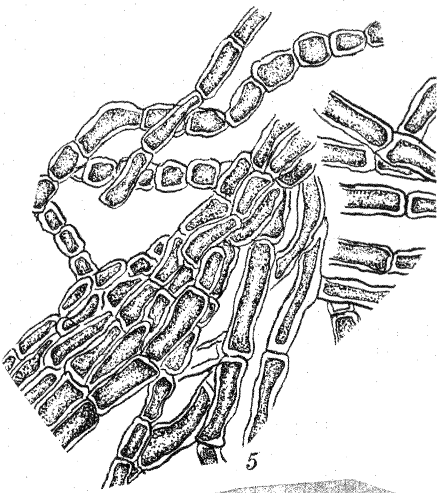

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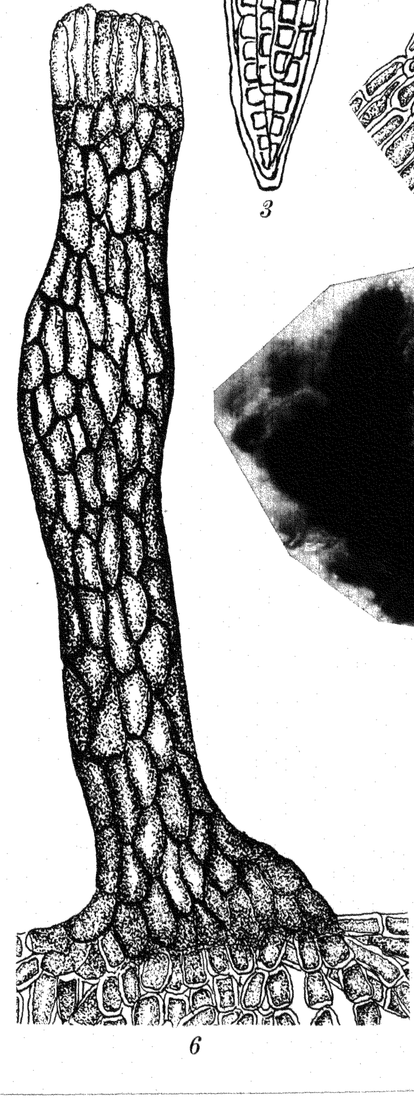

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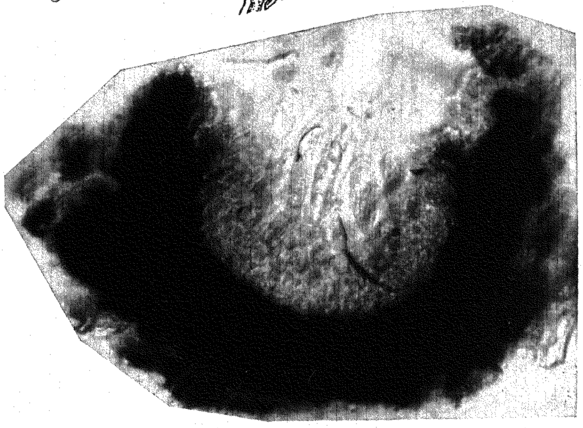

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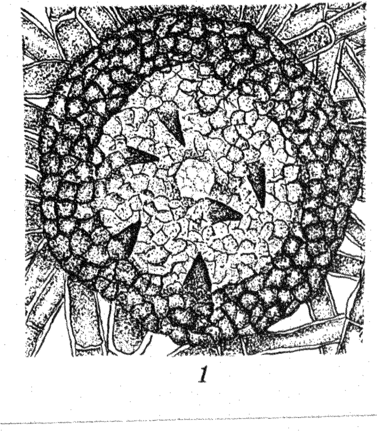

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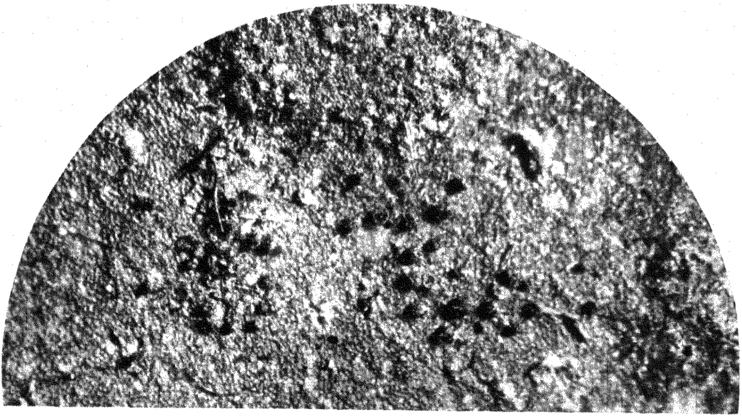

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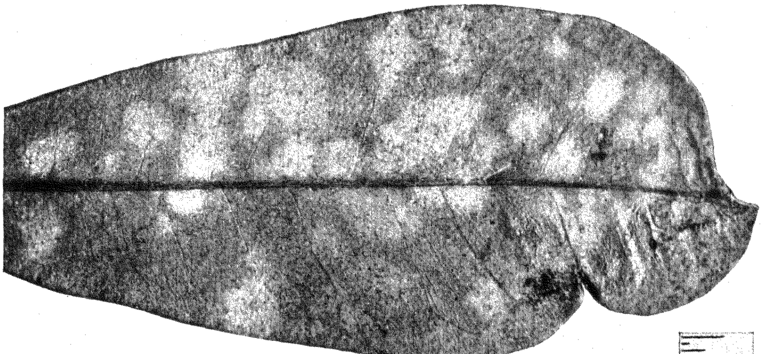

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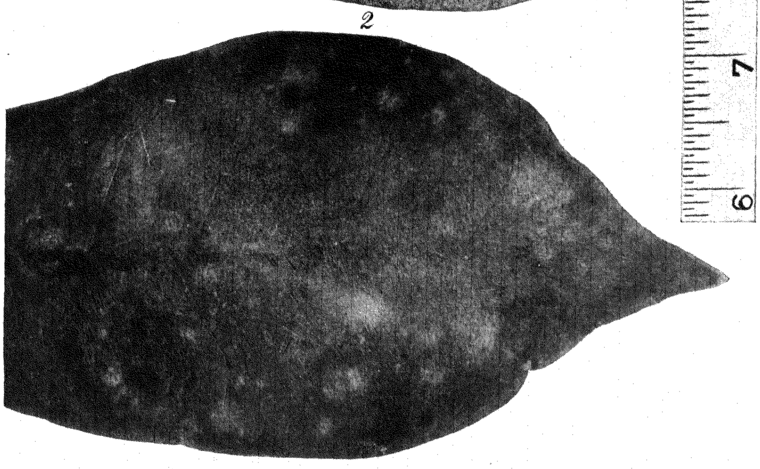

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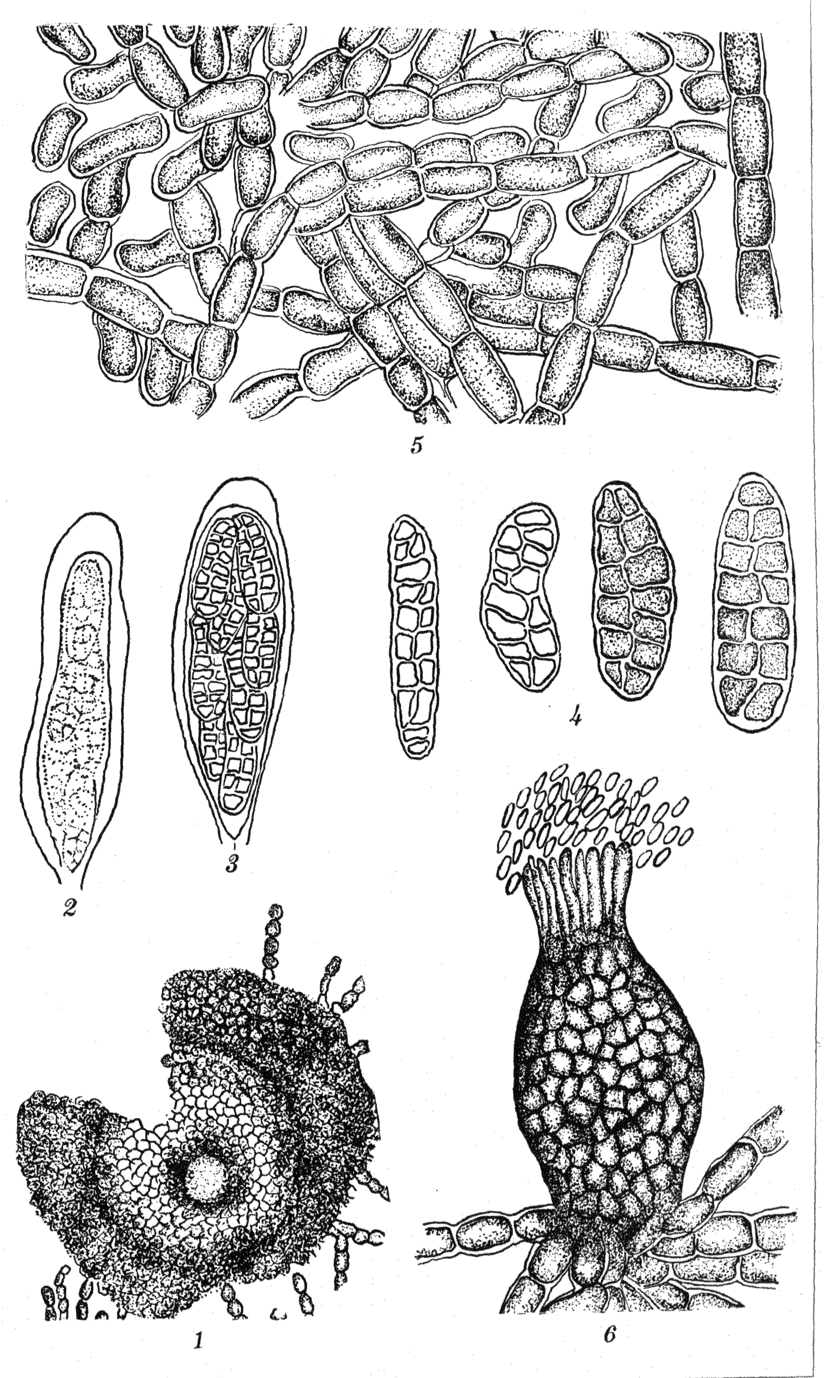


PLATE 10.

NOTES ON THE PHILIPPINE BLACK CORALS

By Leopoldo A. Faustino

Chief Geologist, Bureau of Science, Manila

FIVE PLATES

Several reports have already been made on the Philippine black corals. Seale,[1] calling attention to fine specimens found in Sulu Archipelago, in Davao Gulf, and around Cebu Island and to the large quantities dredged by the U. S. S. *Albatross*, which have been nicknamed "insulated cable wire" by the sailors, referred the specimens to *Antipatharia* sp. Allen,[2] reporting on the chemical analysis, called his specimens *Antipathes abies* (Linn.) Gray. Apparently, the Philippine black corals are not *Antipathes abies* but belong to at least two very distinct and different species. This conclusion is based on examination of identified specimens in the British Museum of Natural History made through the courtesy of Capt. A. K. Totton, keeper of corals, and by comparison of the specimens in the collection of the Bureau of Science with identified specimens, which Dr. Johannes Moser, of the Berlin Museum of Natural History, kindly gave the writer during his visit to Berlin in 1931.

Black corals differ from madreporarian corals in that they are not calcareous or made up entirely of calcium carbonate but are black and with a hornlike skeleton. Among the specimens generally known as Philippine black coral two species are recognized; namely, *Cirripathes anguina* (Dana) and *Cirripathes spiralis* (Linnæus). The general characteristics of the two species as well as the use made of them are set forth in the following paragraphs.

CIRRIPATHES ANGUINA (Dana). Plate 1, figs. 1, 2.

Antipathes anguina DANA, U. S. Expl. Exp. Zoöphytes (1846) 576, pl. 56, figs. 1, 1*a*-1*d*.

Description.—Skeleton hornlike, with a black central axis and a thin cœnenchyma, stalk simple, not branched, flexible when fresh but old specimens brittle and hardly bend, slightly curved or twisted. The longest specimen measures 5 meters, while the largest diameter is 15 centimeters.

---

[1] Philip. Journ. Sci. § D 6 (1911) 307.

[2] Philip. Journ. Sci. 41 (1930) 65.

Spines numerous, crowded, generally at right angles to the surface, irregularly distributed though sometimes simulating longitudinal arrangement. Shape bluntly conical, on old specimens generally flattened out.

Localities.—Sulu Sea, Davao Gulf, and around Cebu (Seale); near Balabac Island, Palawan, collected by Antonio D. Alvir; Albay (?); near Bantayan Island, Cebu, collected by Florencio Talavera; Calapan, Mindoro, collected by Wallace Adams.

Distribution.—Western Pacific, Indian Ocean, Red Sea.

Uses.—Black corals were first used in the Philippines for making canes for which they are particularly adapted by reason of their size and shape. The material is easily worked into any desired shape when fresh, but old specimens are brittle and can be bent only with difficulty and only after immersion in warm salt solution. Sometimes the specimens are kept in water for a month or so before work is begun on them. Philippine black coral takes a beautiful jet-black polish and this quality is taken advantage of in the manufacture of fancy jewelry. The articles shown in the illustrations are manufactured by H. E. Heacock Co., Manila. Both this firm and Florencio Viray, 1666 Juan Luna Street, Manila, who are the largest manufacturers of black-coral jewelry in the Philippines, very kindly permitted the examination of the raw materials and the finished products in their shops.

CIRRIPATHES SPIRALIS (Linnæus). Plate 4, fig. 1.

> *Eucirripathes spiralis* (Blainv.) v. PESCH, Antipatharia Siboga Exped. (1914) 158 with several text figures.

Description.—The following description is based on a single specimen in the Bureau of Science, collected by Florencio Talavera in Jolo Channel, Sulu Archipelago.

Specimen flexible and spirally twisted. Coils rather uniform, varying in diameter from 2 centimeters near the base, where it has been snapped off, to 3 and 4 centimeters in the middle of the section. Diameter of the stalk at the base 4 millimeters, gradually diminishing toward the top, where it measures 1 millimeter. Total length of the specimen, not allowing for the spirals, 56 centimeters.

Spines at right angles to the surface, comparatively much longer than in the preceding species, not as numerous or as closely crowded, generally arranged in longitudinal rows, cylindrical in shape.

Locality.—Jolo Channel, Sulu Archipelago.

Distribution.—Western Pacific, Indian Ocean, Mediterranean, West Indies.

Uses.—This is the species that furnishes most of the material for making earrings and similar objects.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Cirripathes anguina* (Dana); thin transverse section; photomicrograph, × 10.
2. *Cirripathes anguina* (Dana); pieces of main stem.
3. *Cirripathes spiralis* (Linnæus); × ⅓.

PLATE 2

Bracelets, made by H. E. Heacock Co., from *Cirripathes anguina* (Dana). (Courtesy of H. E. Heacock Co.)

PLATE 3

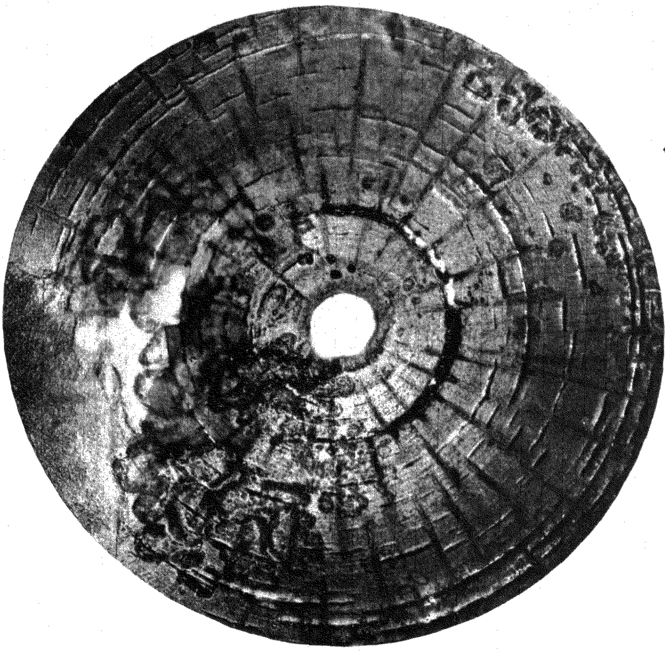
Cigar and cigarette holders, made by H. E. Heacock Co., from *Cirripathes anguina* (Dana). (Courtesy of H. E. Heacock Co.)

PLATE 4

FIGS. 1 and 2. Earrings, made by H. E. Heacock Co., from black corals. (Courtesy of H. E. Heacock Co.)
3 to 6. Earrings, made by H. E. Heacock Co., from *Cirripathes spiralis* (Linnæus). (Courtesy of H. E. Heacock Co.)

PLATE 5

FIG. 1. Finger rings, made by H. E. Heacock Co., from *Cirripathes anguina* (Dana). (Courtesy of H. E. Heacock Co.)
2. Cuff links and scarf pins, made from *Cirripathes anguina* (Dana). (Courtesy of H. E. Heacock Co.)



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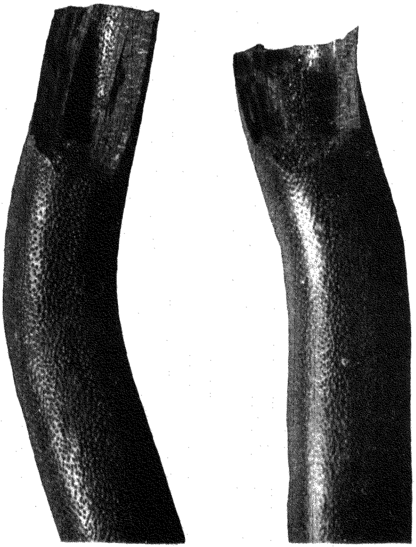

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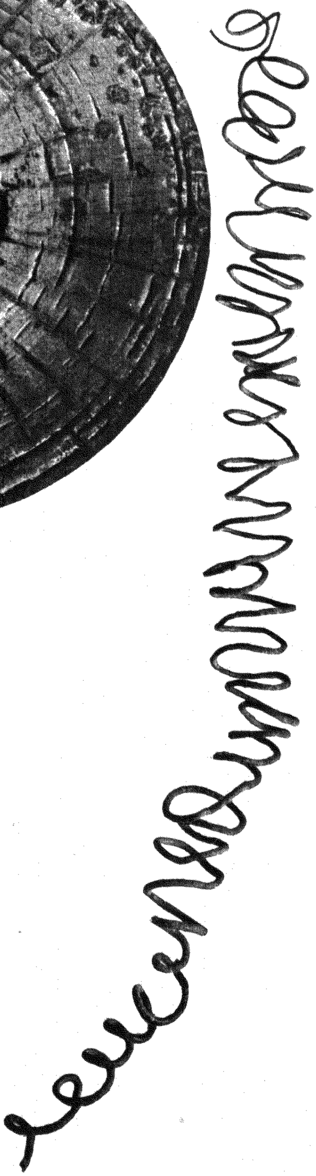

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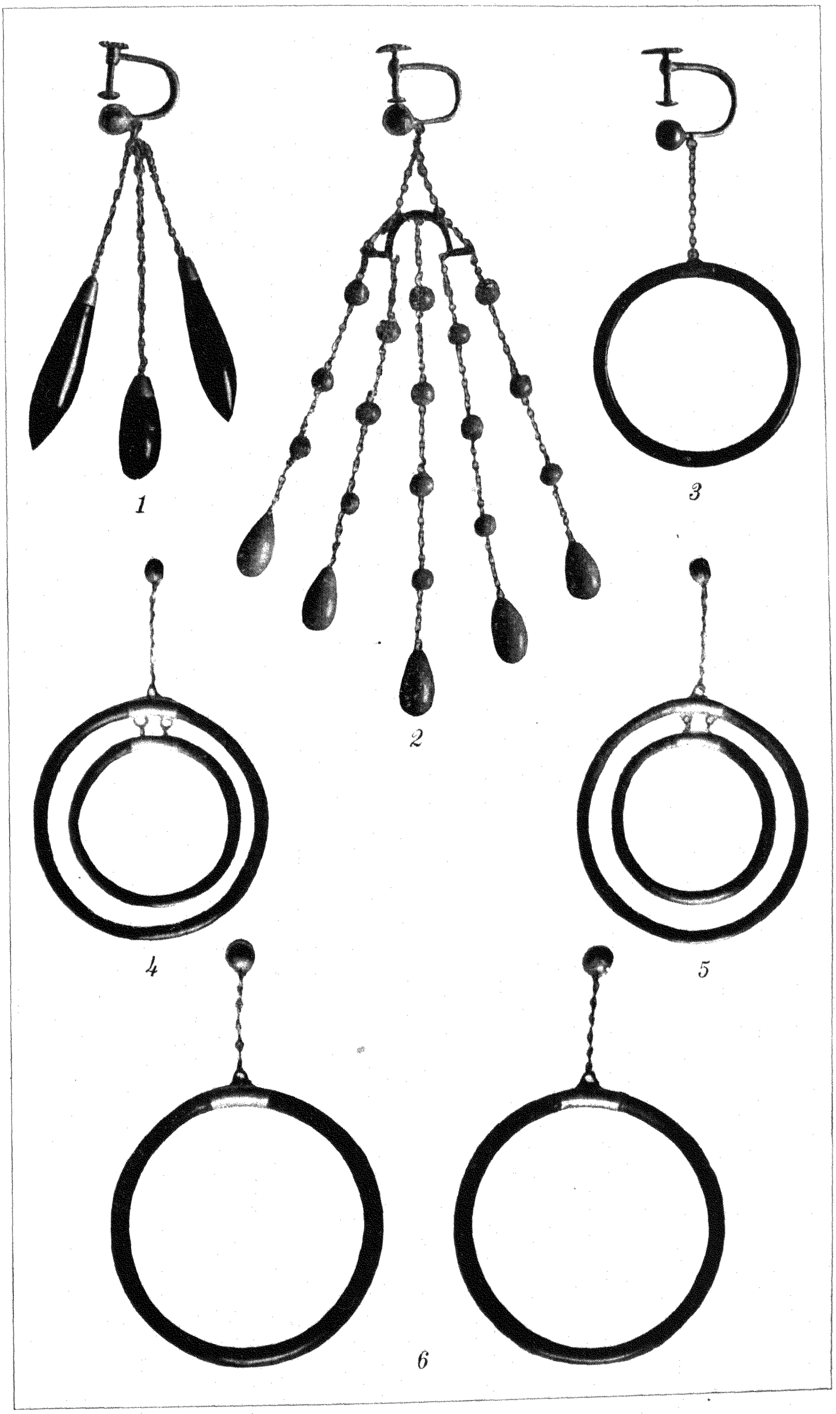
PLATE 1.

PLATE 2.

PLATE 3.



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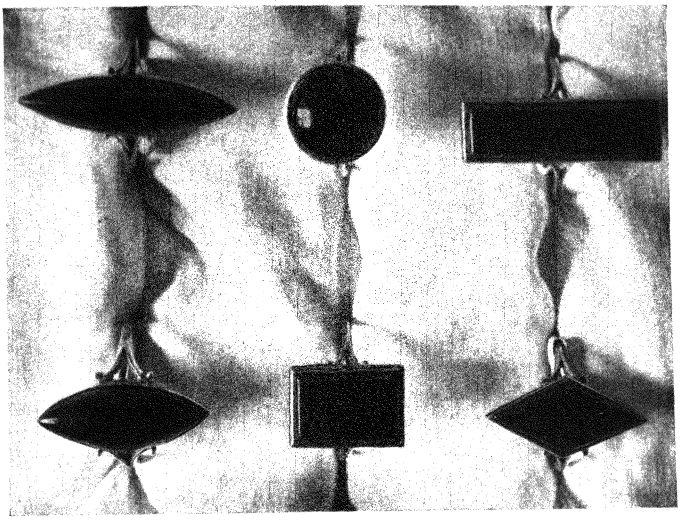

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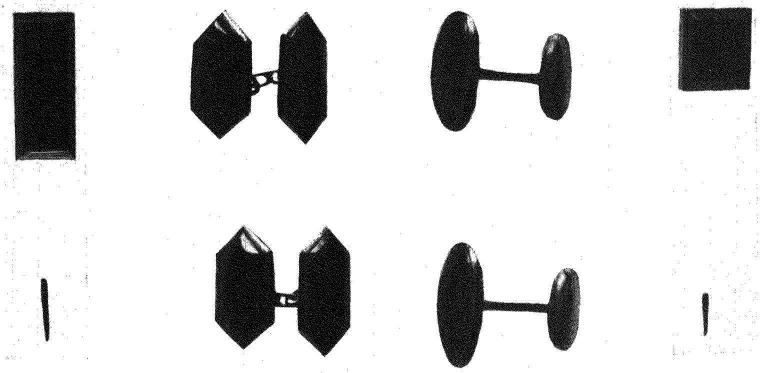

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PLATE 5.

THE DEVELOPMENT OF KARST TOPOGRAPHY IN THE PHILIPPINE ISLANDS

By LEOPOLDO A. FAUSTINO

Chief Geologist, Bureau of Science, Manila

TWO PLATES AND ONE TEXT FIGURE

The characteristic features of karst topography are swallow holes and "karst funnel" or doline, and the regions generally referred to for landscapes of this type are those on the western side of the Balkan Peninsula, in southern France, in the German Jura, and other regions in Europe. At one of the scientific meetings of the Fourth Pacific Science Congress in Java (1929) karst topography in the Tropics was a subject of discussion.[1] Blondel presented his observations in a paper entitled "Karst Phenomena in French Indochina," and P. J. B. van Kessel gave an account of the karst region of the "Duizend Gebergte" (Goenoeng Sewoe, Thousand Hills) in central Java. The present paper embodies the remarks made by the writer regarding the development of karst topography in the Philippine Islands.

Literature on karst formation in tropical regions is not lacking. Hubbard[2] in describing the *pepino* hills of the Lares District, Puerto Rico, came to the conclusion that they "are the byproduct of extensive underground solution and extremely rapid surface solution, combined with the other necessary factors, lithologic and climatic," and that *pepino* hills might be developed anywhere in the tropical zone.[3]

The first requisite to form karst topography is a limestone or calcareous formation. It should be remembered, however, that not all limestone or calcareous formation will form karst topography. Limestone or calcareous formations are of general distribution in the Philippine Islands and are encountered not only along the coast in narrow strips and at high elevations in patches but also in the central regions and occupying extensive areas. The best development of karst topography in the Philippine Islands is in central Bohol (one of the larger islands of the Visayan group) in the vicinity of Carmen. It presents all the characteristic topographic features of Goenoeng Sewoe, Thousand Hills of central Java, which I had the pleasure and the privilege of seeing during one of the excursions of the Fourth Pacific Science Congress in 1929. The Bohol hills will be referred to in this paper as the Carmen Thousand Hills.

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[1] Proc. Fourth Pac. Sci. Congress 1 (1930) 282.

[2] Scientific Survey of Porto Rico and the Virgin Islands 2 pt. 1 (1923) 93.

[3] Also Salomon, W., Karrenfelder in Warmem Klime, Centr. f. Min. 1926 B. 529–30 (1926), unfortunately not available at the time in the Bureau of Science library.

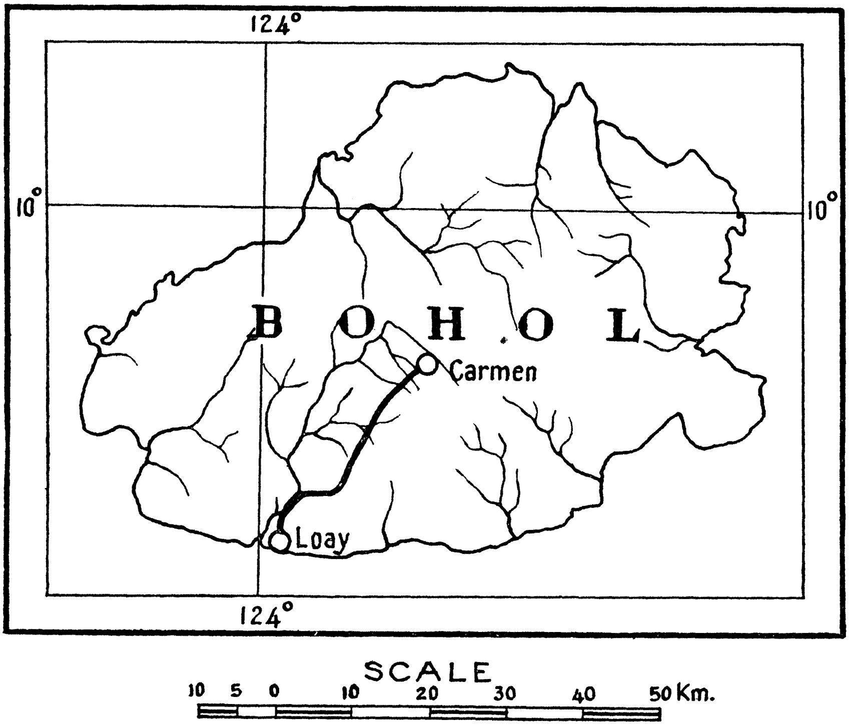

FIG. 1. Bohol Island.

The Carmen Thousand Hills were seen by Warmen D Smith,[1] who described them as a "remarkable series of 'haycock' hills (hundreds of them) in the central part, in the vicinity of Carmen, all alike, having the appearance of a small archipelago of small limestone islands raised some 700 meters,"[2] but who offered no explanation. Doctor Dickerson[3] was of the opinion that "the rounded hills, which rise above the general level of this terrace, probably represent a series of stacks that have been rounded by erosion since the general region was uplifted." My own introduction to this very interesting topography was in March, 1929, when the Director of the Bureau of Science sent me to Loay in southern Bohol to investigate a crack in the ground which was "becoming wider and deeper from time to time." The crack was described by Mr. Fidel Bacol, municipal president of Loay, in his letter to the Department of Agriculture and Natural Resources as follows:

---

[1] Geology and Min. Res. P. I. Bur. Sci. Pub. 19 (1925) 195.

[2] Mr. Emilio Buenaventura, district engineer of Bohol, estimated the summit of the hills as 400 meters above sea level, in a personal communication to the writer.

> I have the honor to report to this Department the following occurrence:
>
> 1. That Tayong is a barrio along the coast, at the eastern side of the town of Loay, Province of Bohol, at a distance of seven kilometers from the municipal building of the Municipality of Loay, with a population of approximately three hundred-fifty souls living distributively. The area of this barrio is about two square kilometers. It is hilly and the upper part is a place of almost solid rocks.
>
> 2. That a year ago the upper part of this barrio at a distance of about one and one third kilometers from the coast, began to crack in a linear form from east to west. The cracking is rapidly progressing, thus making now a length of about a kilometer. The crack is becoming wider and deeper from time to time. Herewith are sent two views of the middle part of the crack.
>
> 3. That at present the people of this barrio fear the sign of rapid progress of the crack, so that some of them are now entertaining the idea of deserting the place concerned.
>
> For certainty and safety of lives and property, I have the honor to request the Honorable Secretary of Agriculture and Natural Resources to send as early as possible an expert for physical observation and examination of the place concerned.

The results of this investigation and of the following field trip to Carmen in north-central Bohol form the basis of this report.

TOPOGRAPHY OF THE CARMEN THOUSAND HILLS

The Carmen Thousand Hills cover an area in central Bohol in the vicinity of Carmen of approximately 100 square kilometers. The hills are roughly conical or mound-shaped, and as far as could be ascertained at the time of my visit are distributed over the area with an irregular alignment. With a topographic map or an airplane photograph some alignment may be deciphered. Sometimes the bases of adjoining hills joined each other forming U-shaped troughs. At other times there are, however, wide open spaces between the hills. Mr. Emilio Buenaventura, district engineer of Bohol, estimated the average height of these hills as approximately 30 meters and their mean diameter at the base as about 65 meters. When first seen from a distance they present an array of great mounds, like stacks of palay, as if the whole region had just finished a big harvest and all the palay were heaped on both sides of the road. The hills are so numerous that the name Carmen Thousand Hills is fairly descriptive. As the region is covered mainly with shrub and grass vegetation and there are few trees, the sight is imposing and one that impresses the visitor long after he has seen the place. The summits of these conical hills rise to about the same elevation and from the top of one of them it is not difficult to discern the old plateau surface or elevated marine terrace which once occupied the whole region. The slopes of the hills are flowing lines and the region has already reached late maturity, perhaps early old age.

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[3] Tertiary Paleogeography of the Philippines, Philip. Journ. Sci. 25 (1924) 49. Explanatory note Plate 1, fig. 2.

ORIGIN OF THE CARMEN THOUSAND HILLS

The origin of these hills may best be deciphered by reference to the origin of the crack at the barrio of Tayong, Loay. The crack first appeared on the top of a hill on one side of which a stream has already deepened its channel sufficiently low to throw out of adjustment its underground tributary passing through the hill. As this underground tributary began to lower its channel caverns started to form. At the time that the cracks appeared on the surface the caverns had grown sufficiently large and the roof sufficiently weak to permit a collapse. The result was the formation of a long collapse sink which the President of Loay referred to as the crack extending east and west.

Upon examination the walls of the crack were found to be calcareous formation with bits and triturated madreporarian corals and shells. Few good fossil specimens were found. The formation is distinctly porous and one that will permit free underground water circulation sufficiently rapid to form caverns. It does not show signs of bedding but apparently is just a mass of calcareous materials.

The Carmen Thousand Hills are composed of similar calcareous materials, if the quarry of the Bureau of Public Works for road materials on one of the hills near the road could be taken as a criterion. The summit of the hills is approximately 400 meters above sea level. In other words, the original land surface of the elevated plateau or marine terrace was sufficiently high for the formation of sink holes and swallows by descending meteoric waters. As sinks began to be numerous and underground drainage well developed numerous caverns were formed and collapsed. The portions that remained intact are now the summit of the hills, while the valley bottoms are the channels of the underground streams laid bare by collapse. Bohol, at least this particular region, has remained stationary sufficiently long for the formation of the peculiar topographic features. The climate of Bohol, with no strongly pronounced maximum rain period and no dry season, and the apparently uniform lithologic character of the calcareous formation both helped in the development of these interesting topographic details, which are found only in Bohol. At least, my ten years field work in different parts of the islands has not revealed anything similar.

While calcareous or limestone formations are very widely distributed throughout the Archipelago, no area has produced topographic features similar to the Carmen Thousand Hills. The northern portion of Cebu Island is a recently elevated coral reef, not very high above sea level, and has but incipient solution sinks and slightly developed underground drainage. The hard, fine-grained limestone in different parts of Luzon forms cliffs and sometimes needles as at Sagada, Mountain Province, rather than conical hills. It is, therefore, the conclusion of the writer that karst topography developed in Bohol Island because of a combination of circumstances including rock formation, elevation, chemical and mechanical erosion, climatic and other factors and that these factors have been permitted to work their natural course without interruption for a sufficiently long period of time to form the Carmen Thousand Hills.

ILLUSTRATIONS

PLATE 1

THE COLLAPSED SINK AT BARRIO TAYONG, LOAY, BOHOL

FIG. 1. Inhabitants of the barrio gathered at the widest portion. (Photograph sent by Fidel Bacol.)
2. Another view of the collapsed sink.
3. Cracks that form part of the collapsed sink.

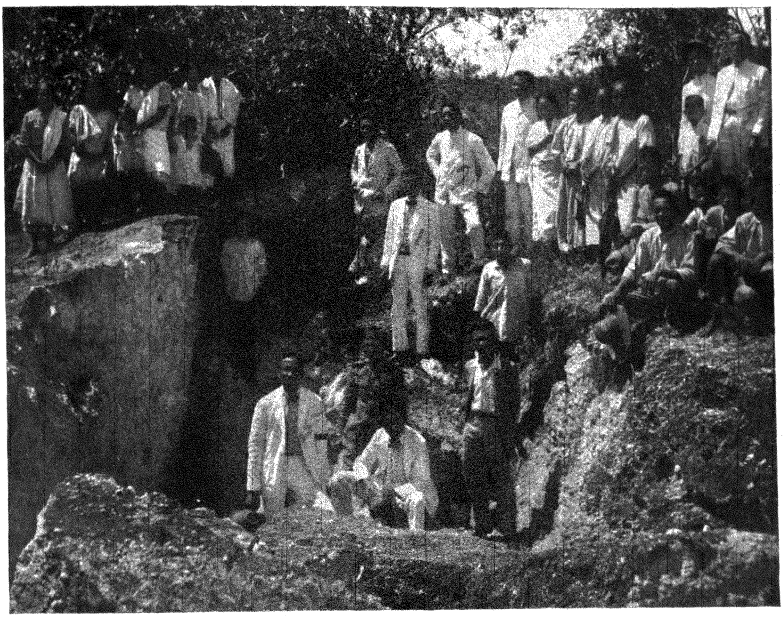
PLATE 2

THE CARMEN THOUSAND HILLS

FIGS. 1 and 2. General views of the district showing arrangement and general appearance of the hills from a distance.
FIG. 3. A close-up view of one of the hills showing vegetation.

TEXT FIGURE

FIG. 1. Map of Bohol Island.



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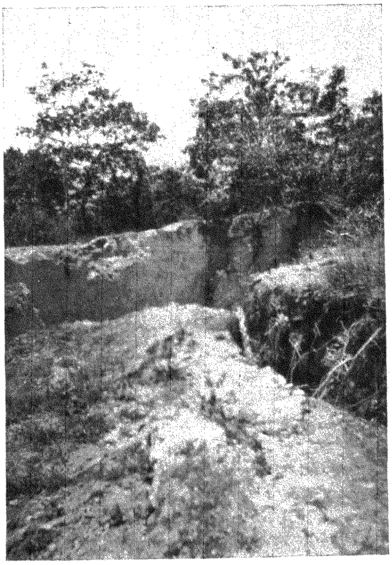

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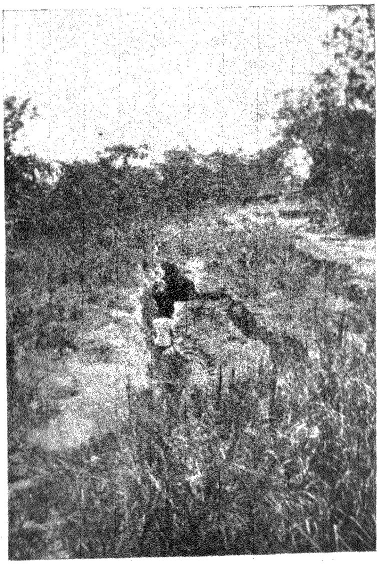

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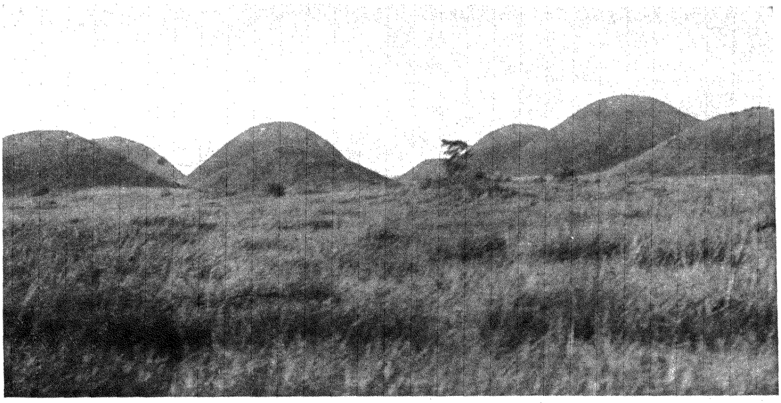

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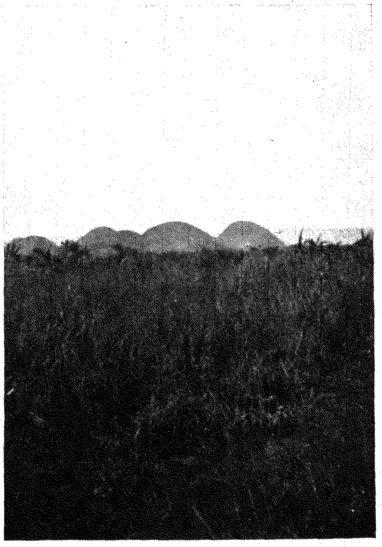

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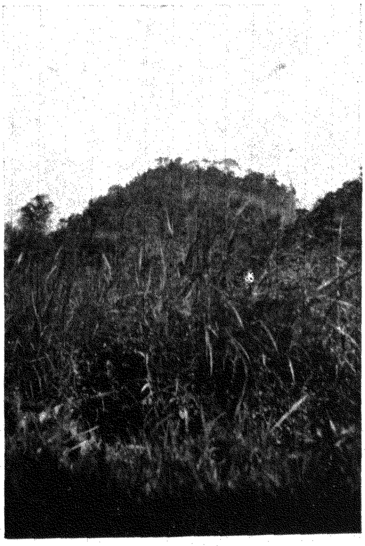

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PLATE 2. VIEWS OF CARMEN THOUSAND HILLS.

EXPERIMENTS WITH VARIOUS TOXIC SUBSTANCES PARTIALLY ADSORBED ON CHARCOAL AS AN ANOPHELES LARVICIDE

LARVICIDE STUDIES, IV[1]

By AUGUSTUS P. WEST
Of the Bureau of Science, Manila

and

PAUL F. RUSSELL
Of the International Health Division of the Rockefeller Foundation

ONE PLATE

In previous papers[2] some experiments were reported in which Paris green and other arsenicals mixed with charcoal or partially adsorbed on it were used as an anopheles larvicide. Further studies have been undertaken to test the larvicidal properties of reputedly insecticidal substances partially adsorbed on charcoal. The results are recorded in this paper.

EXPERIMENTAL PROCEDURE

The technic used in these experiments was the same as explained in our previous papers. *Anopheles subpictus* and *A. hyrcanus* var. *sinensis* larvæ in third and fourth stages of development were used. Enamel pans were filled with artesian water so that they had a surface area of 532 square centimeters and a depth of 5 centimeters. Larvæ were not pronounced dead until all motion had ceased. They were then removed to separate beakers of water to guard against possible mistakes in diagnosis or counting. The amount of mixture used was less per area than that advocated for field use. Control pans were used with the same number and species of larvæ, the same amount of water and external influences. The larvæ had no difficulty in filling their digestive tracts with the treated charcoal and after about one to two hours there was a continuous flow of charcoal through the gut of each larva for twenty-four hours (and in some cases for seventy-two hours).

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[1] These studies were undertaken by the divisions of organic chemistry and of malaria investigations, Bureau of Science. The division of malaria investigations is coöperatively supported by the bureau and by the International Health Division of the Rockefeller Foundation.

[2] Russell, P. F., and A. P. West, Philip. Journ. Sci. 48 (1932) 291. West, A. P., and P. F. Russell, Philip. Journ. Sci. 48 (1932) 545. Russell, P. F., and A. P. West, Philip. Journ. Sci. 49 (1932) 97.

RESULTS

The results of these experiments have been almost entirely negative but are of considerable use in comparison and contrast to the tests reported in our previous papers. These tests help in the attempt to evaluate the usefulness of certain insecticides as anopheles larvicides.

It was surprising that such potent substances as nickel chromate (test 36) and barium chloride (test 115), when combined with charcoal, were without effect on anopheles larvæ. No absorption whatever apparently took place in the gut of the larvæ. Yet barium chloride has a high reputation as an insecticide and is so poisonous to man that 4 to 5 grams will prove fatal. Bourcart [3] states that this salt, when absorbed with food, kills insects as rapidly as arsenical preparations. Paris green and arsenic trioxide are difficultly soluble in water and are only partially adsorbed by charcoal. Barium chloride is very soluble in water and is adsorbed readily by charcoal. Possibly the barium chloride clings to the charcoal more tenaciously than Paris green and therefore is not released in the gut of the larva as are the arsenicals when similarly introduced on charcoal. In a 3 per cent concentration (test 115) it was wholly impotent against anopheles larvæ.

Pyrethrum powder partially adsorbed on charcoal in 1 and 3 per cent concentrations proved to be relatively ineffective. This substance, obtained from the powdered flower heads of *Chrysanthemum cinerariaefolium* (Trev.) has long been recognized as an insecticide,[4] but in these experiments using a low concentration, because it would be economically unfeasible in practice in greater amounts, the pyrethrum seems to have no value as an anopheles larvicide. Two types of extracts were used, one the usual kerosene preparation and the other a chloroform extraction.

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[3] Bourcart, E., Insecticides, Fungicides, and Weedkillers (1913) 138.

[4] Bourcart, E., Insecticides, Fungicides, and Weedkillers (1913) 378. McIndoo, N. E., and A. F. Lievers, U. S. Dept. Agr. Bull. 1201 (1924) 6 and 31.

Nicotine is another vegetable product which has found a usefulness as an insecticide but which in these experiments has been disappointing (test 56). In this case a water extract of mature tobacco was used; the exact concentration on the charcoal was not determined.

So, too, tannic acid (tests 59 and 60) are nitre cake (test 48) were ineffective. The later is acid sodium sulphate, or sodium bisulphate, a by-product in the manufacture of nitric acid. It has been suggested from time to time as a larvicide. Metz,[5] for example, reported it to be fairly efficient. Eckstein[6] tried it with poor results against larvæ of *Culex pipiens*. Allen,[7] however, found that it destroyed larvæ of *Aëdes solicitous* in three hours. In our experiment (test 48) an 8 per cent concentration failed to kill anopheles larvæ.

Rotenone (test 112), in the low concentration of 0.4 per cent, killed about one-third of the larvæ in twenty-four hours. This substance is the insecticidal principle of the root of *Derris elliptica* and has been advocated for use against a variety of insects, including mosquitoes. On charcoal it does not appear to have any greater potency than Paris green which is less expensive.

SUMMARY

Certain heavy metallic poisons and some miscellaneous nonarsenical substances partially adsorbed on powdered charcoal have been tested for larvicidal properties against anopheles larvæ but none was found to be as effective as Paris green.

[5] Metz, C. W., U. S. Pub. Health Rep. 34 (1919) 167.

[6] Eckstein, F., Zeits. Angew. Entom. Berlin 6 (1920) 338.

[7] Allen, A. H., U. S. Naval Med. Bull. 16 (1922) 1.

TABLE 1.—*Larvicidal effect of some reputedly insecticidal substances partially adsorbed on charcoal.*

Test No.	Substance used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods (hours). Cumulative totals.										Weight of larvicide.
				1.25	2.5	3	4	5	6	7	24	48	72	
		Per cent.												*g.*
41	Control	----------	50	0	0	0	0	0	0	0	4	4	------	----------
35	Nickel carbonate	3.0	50	0	0	0	0	0	0	------	2	4	4	0.30
	Lime	0.5												
36	Nickel chromate	3.0	50	0	0	0	0	0	0	------	2	2	2	0.13
	Lime	0.5												
37	Nickel oxalate	3.0	50	0	0	0	0	0	0	------	0	0	0	0.13
	Lime	0.5												
61	Antimony trioxide	3.0	10	0	0	0	0	0	0	------	0	0	0	(b)
55	do	3.0	50	0	0	0	0	0	0	------	0	------	------	0.13
	Lime	0.5												
9	Copper carbonate	4.0	50	0	0	0	0	4	4	------	42	------	------	0.13
	Oxalic acid	2.0												
34	Copper oxalate	3.0	50	0	0	0	0	0	0	------	0	2	2	0.13
	Lime	0.5												
32	Barium carbonate	3.0	50	0	0	0	0	0	0	------	0	0	2	0.13
	Lime	0.5												
115	Barium chloride	3.0	50	0	0	0	0	0	0	------	6	------	------	0.10
33	Barium chromate	3.0	50	0	0	0	0	0	0	------	0	0	2	0.13
	Lime	0.5												
45	Barium oxalate	3.0	50	0	0	0	0	0	0	------	0	------	------	0.13
	Lime	0.5												
44	Calcium oxalate	3.0	50	0	0	0	0	0	2	------	4	------	------	0.13
	Lime	0.5												
30	Oxalic acid	10.0	50	[a] 2	2	2	2	2	2	------	2	2	4	0.13
48	Nitre cake	8.0	50	0	0	2	2	2	2	------	2	------	------	0.13
49	Pyrethrum (kerosene extract)	3.0	50	0	0	2	4	8	8	------	12	------	------	0.13

162	Pyrethrum (chloroform extract)	1.0	50	0	0	0	0	0	0	------	0	------	------	0.10
54	Cinnamic acid	3.0	50	0	0	0	0	0	0	------	0	------	------	0.13
56	Nicotine	c0.5	50	0	0	0	0	0	0	------	0	------	------	0.13
59	Tannic acid Lime	3.0 0.5	10	0	0	0	0	0	0	------	0	0	0	(b)
60	Tannic acid	3.0	10	0	0	0	0	0	0	------	0	0	0	(b)
112	Rotenone	0.4	50	0	0	2	2	2	2	2	34	------	------	0.10
157	(P) Nitro phenol	1.0	50	0	0	0	0	0	0	6	6	------	------	0.10

[a] Tests were made at intervals of 15, 30, 45, 60, 75, 90, and 105 minutes. In each case negative results were obtained except in test 30 at the 75 minute (1.25 hour) period which gave two dead larvæ.

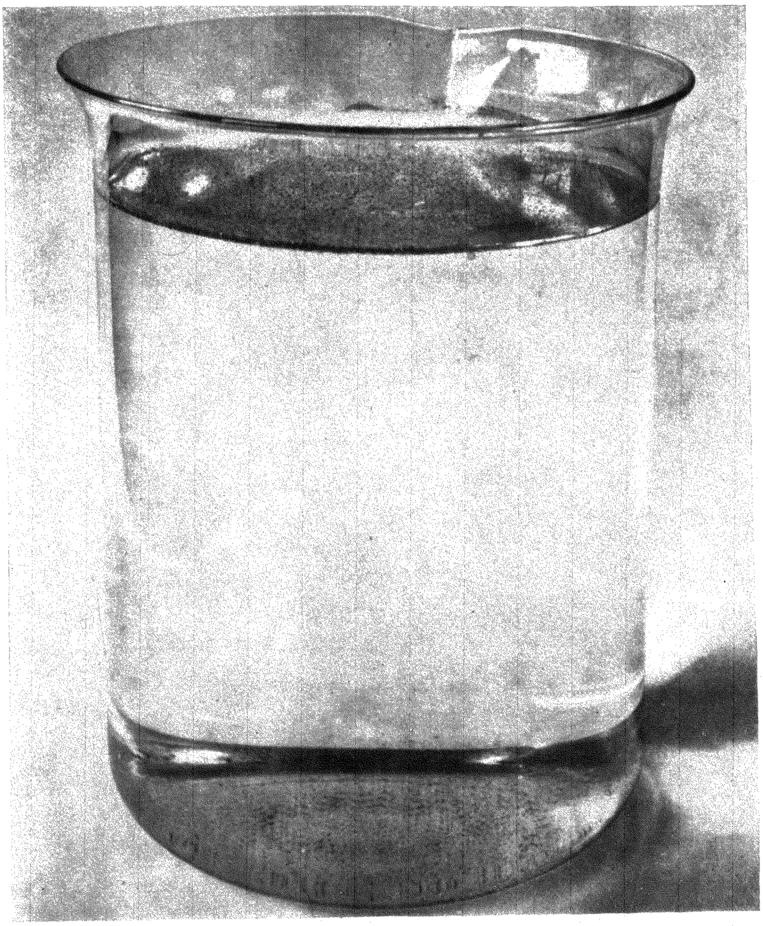
[b] Enough to cover surface.

[c] Concentration estimated.

ILLUSTRATION

PLATE 1

FIG. 1. Charcoal on water.
2. Mosquito's gut containing charcoal.



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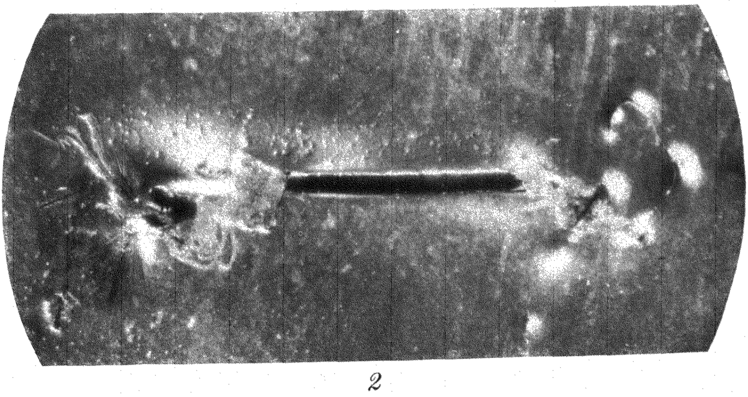

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PLATE 1.

ANOPHELES MINIMUS LARVÆ FROM WELLS IN LAGUNA PROVINCE, PHILIPPINE ISLANDS[1]

By PAUL F. RUSSELL

Of the International Health Division of the Rockefeller Foundation

and

DOMINGO SANTIAGO

Field Inspector, Malaria Investigations, Manila

ONE PLATE

INTRODUCTION

The common carrier of malaria in the Philippine Islands is *Anopheles minimus.*(1, 2, 3, 4) Its larvæ are found, typically, at the edges of small, clear, flowing streams in shady places where there are clean roots, especially of bamboo, or where there are large stones or undercut banks. They may be found sometimes among drift débris or in small rocky pools recently isolated from a stream. Sometimes they are taken at the margins of large rivers if a steep bank affords acceptable shelter. They may be found in irrigation ditches and occasionally elsewhere.(5, 6, 7, 8, 9)

The purpose of this paper is to report the discovery of *A. minimus* larvæ in wells, a previously unrecognized breeding place of this important species in the Philippine Islands.

TECHNIC

A survey of wells in Masiit and Calauan, Laguna Province, Luzon, was ordered on a chance that anopheline larvæ might be found in them, although there are typical breeding places in abundance for *A. minimus, A. barbirostris,* and other species common in these localities. A special dipper was devised (Plate 1), and wells were searched systematically.

RESULTS

In Table 1 are given the results of this survey of wells in Masiit and Calauan. It will be seen that *A. minimus* (typical), *A. barbirostris,* and *A. vagus* var. *limosus* were taken from wells, occasionally in fair numbers. These wells are of the

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[1] This report is from the Calauan laboratory of malaria investigations, a project jointly supported by the Bureau of Science, Manila, and the International Health Division of the Rockefeller Foundation.

TABLE 1.—*Anopheline larvæ in wells in Laguna Province, Luzon.*

Date.	Place.	Well.				Anopheline larvæ.		Adults bred out.	
		Owner.	Depth.		Diameter.	Species.	Number.	Males.	Females.
			Top to surface.	Water.					
1932			*in.*	*in.*	*in.*				
March 2	Masiit	F. G.	74	46	50	*Anopheles minimus*	1	0	0
March 2	do	J. M.	85	59	68		0		
March 2	do	L. N.	64	47	79	*Anopheles minimus*	17	5	6
						Anopheles barbirostris	2	0	0
March 2	do	R. P.	74	48	60	do	1	0	1
March 2	do	C. I.	79	47	48		0	0	0
March 2	do	M. C.	117	59	27	*Anopheles minimus*	4	1	0
March 2	do	F. P.	66	40	36	do	1	0	0
						Anopheles barbirostris	2	1	1
March 2	do	V. B.	67	53	52		0		
March 2	do	B. P.	35	40	35		0		
March 30	Calauan	P. A.	73	57	40		0		
March 30	do	R. B.	63	42	33		0		
March 30	do	I. G.	60	47	53		0		
March 30	do	P. S.	84	45	36		0		
March 30	do	J. M.	46	57	36		0		
March 30	do	S. C.	72	40	34		0		
March 30	do	A. R.	74	55	46		0		
March 30	do	A. M.	88	43	31		0		
March 30	do	R. E.	68	58	66	*Anopheles minimus*	7	0	0
March 30	do	F. M.	43	82	46	do	1	0	0
April 6	do	S. M.	37	38	32		0		
April 6	do	R. M.	76	68	32		0		

April	6	do	N. K	75	39	39		0		
April	6	do	M. V	51	44	41		0		
April	6	do	M. M	55	17	39		0		
April	6	do	C. P	41	53	56	*Anopheles minimus*	10	0	0
April	6	do	I. M	87	52	38	*Anopheles vagus* var. *limosus*	1	1	0
April	6	do	G. P	59	48	52	*Anopheles minimus*	8	0	0
April	6	do	M. I	49	56	55		0		
April	6	do	D. M	53	22	33	*Anopheles minimus*	1	0	0
April	6	do	M. H	37	51	39		0		
April	6	do	I. P	30	74	34		0		
April	6	do	E. A	31	60	39		0		
April	6	do	L. K	34	55	60	*Anopheles barbirostris*	2	0	0

surface type (Plate 1). The water is usually clear, but is not flowing within the wall itself. As a rule, the water is used not for drinking but for bathing and miscellaneous purposes.

Malaria is present in both Calauan and Masiit. For example, Russell(9) recently examined eighty-two school children in Calauan and found a spleen index of 36.6 per cent. *Anopheles minimus* larvæ are abundant in the streams of this region.

How much of a factor these wells may be in the epidemiology of malaria has not been determined. In view of the large numbers of larvæ always to be found in the streams and the relatively few to be found in the wells, it is probable that in this region wells are not an appreciable factor in malaria transmission. In the regions where a pronounced dry season causes a disappearance of the typical stream breeding places of *A. minimus,* it is conceivable that wells might be a factor in continuing the propagation of this species and, perhaps, therefore, also of malaria. This question requires further study.

SUMMARY

Larvæ of the chief malaria carrier, *A. minimus,* and of *A. barbirostris* and *A. vagus* var. *limosus* are here reported, apparently for the first time, as breeding in surface wells in Laguna Province, Philippine Islands.

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4. KING, W. V. Three species of the minimus-funestus group in the Philippine Islands. Philip. Journ. Sci. (August, 1932) (to be published).
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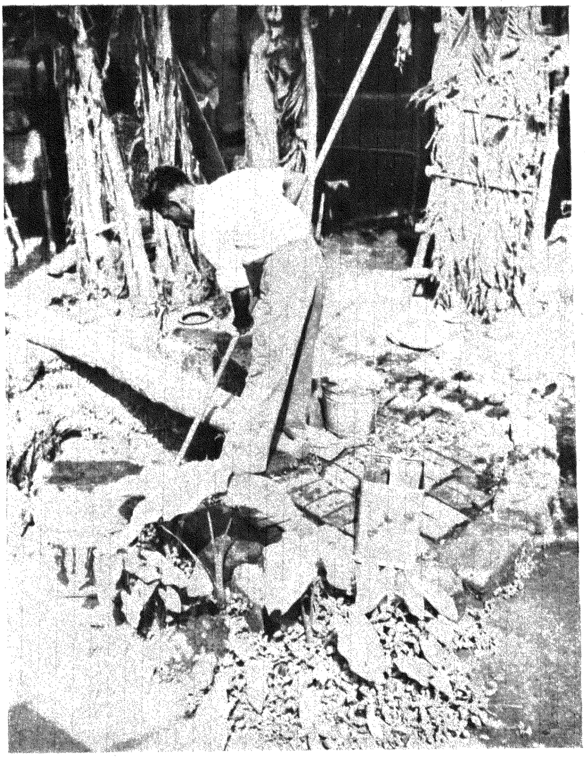
ILLUSTRATION

PLATE 1

FIG. 1. A sanitary inspector with special dipper for catching anopheles larvæ in wells.

2. Special dipper for use in wells, with a joint that permits angulation of the handle.
3. A surface well in Calauan, Laguna Province, Luzon, from which typical larvæ of *Anopheles minimus* were taken.



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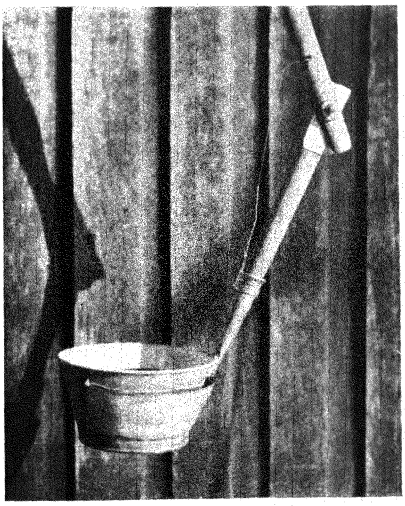

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PLATE 1.

AVIAN MALARIA STUDIES, VI

SUSCEPTIBILITY OF LUTZIA FUSCANA (WIEDEMANN) EDWARDS TO AVIAN MALARIA[1]

By ANDRES M. NONO

Chief Inspector, Malaria Investigations, Manila

ONE PLATE

INTRODUCTION

Huff (1927) summarized the species of mosquitoes susceptible to bird malaria as shown in Table 1.

TABLE 1.—*Species of mosquitoes known to be susceptible to bird malaria.*

Species.	Worker and year.
Culex (*Culex*) *hortensis* Ficalbi, 1889.	Sergents, 1918.
Culex (*Culex*) *quinquefasciatus* Say, 1823.	Ross, 1898.
Culex (*Culex*) *pipiens* Linnæus, 1758.	Ruge, 1901.
Theobaldia longeareolata Macquart, 1838.	Sergents, 1918.
Aëdes (*Ochlerotatus*) *mariae* Ed. Sergents, 1903.	Sergents, 1918.
Aëdes (*Ochlerotatus*) *communis* De Geer, 1776.	Koch, 1899.
Aëdes (*Stegomyia*) *ægypti* Linnæus, 1762.	Sergents, 1907.
Culex territans Walker, 1856.	Huff, 1927.
Culex salinarius Coquillet, 1904.	Huff, 1927.

The last two mentioned species were reported for the first time as susceptible to infection with three species of *Plasmodium* of birds (*cathemerium, praecox,* and *inconstans*). No record of avian malaria infection for *Lutzia fuscana* (Wiedemann) Edwards has been published previous to this account.

For this reason it seems worth while to report positive results on this species. Possibly workers in similar studies may use this species as laboratory material in studying other aspects of malaria.

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[1] From the laboratory of malaria investigations, Paul F. Russell, chief. This project is jointly supported by the International Health Division of the Rockefeller Foundation and the Bureau of Science, Manila. I wish to acknowledge my indebtedness to Doctor Russell in connection with this experiment.

OBJECT

(*a*) To determine the susceptibility of *L. fuscana* for *Plasmodium cathemerium* Hartman, 1924.

(*b*) To determine the susceptibility of the same species of mosquito for *P. capistrani* Russell, 1932.

MATERIALS AND TECHNIC

The birds used in this experiment as host of the parasite were canaries (*Serinus canarius*). The parasites used were *Plasmodium cathemerium* and *P. capistrani.* The mosquito host of the parasite was *Lutzia fuscana.*

Newly emerged adults were used in the experiment. Feeding upon the birds was done at night. The newly emerged adults were first kept three days after emergence in a moist lamp chimney. Sweetened raisins were placed on top of the moistened chimney as food for the mosquitoes. After three days, the insects were transferred from the lamp chimney to a rectangular screened mosquito cage (12 by 12 by 20 inches). Before dusk a heavily infected bird was tied in a small cage (5 by 5 by 5 inches), which was placed within the mosquito cage. The following morning, the engorged females were picked out and placed in a moist lamp chimney for incubation at room temperature.

EXPERIMENT AND RESULTS

SUSCEPTIBILITY OF L. FUSCANA FOR P. CATHEMERIUM

June 29, 1931, two mosquitoes fed upon bird NI, which at that time was heavily infected with parasites. The parasite and red-cell counts on the blood smear, properly stained, are shown in Table 2. Six and one-half days later the mosquitoes were dissected for oöcysts on the stomach. One was negative and the other positive, with a well-defined oöcyst (Plate 1, fig. 1). It measured 33 microns in diameter at this age. The protoplasm was granular with the characteristic pigment in clumps and more or less obscured. One could not mistake an oöcyst at this age because of the definite cyst wall, the characteristic pigment, and its position in the stomach wall. It is of interest to note, however, that we have observed that some oöcysts develop on the inside wall of the stomach. This could be detected by rolling the stomach over until the oöcyst reached the edge of the flattened stomach. If the oöcyst is located on the outside wall it projects, but remains attached to the stomach wall by a narrow constricted neck of muscle tissue which has been distended. On the other hand, if the oöcyst develops on the inside wall of the stomach, we do not notice this bulging out. The cyst simply follows the rolling of the stomach. After some practice we could detect the location of the cyst by focusing the fine adjustment.

TABLE 2.—*Summary of parasite and red-cell counts in birds from which mosquitoes were infected.*[a]

Date.	Bird No.	Parasites per 10,000 red blood cells.	Gametocytes.		Mosquitoes.	
			Per cent.	Per 10,000 red blood cells.	Dis-sected.	Positive.
June 29, 1931	[b] N-1	8,088	4.3	348	2	1
August 12, 1931	[b] N-35	290	8.6	25	1	1
March 3, 1932	[c] Y-92	181	23.6	25	1	1

[a] Miss Filomena Villacorta, microscopist of the staff of malaria investigations, assisted in counting the red cells and parasites in the blood smears.

[b] Infected with *P. cathemerium.*

[c] Infected with *P. capistrani.*

August 12, 1931, it was decided to check and confirm the first result. One mosquito fed upon bird N–35; blood heavily infected with the same species of *Plasmodium.* The parasite and red-cell counts are shown in Table 2. On dissection of the stomach seven days after the blood meal, nine oöcysts were counted on both sides of the stomach. On further examination with the higher power, the formation of a granular streak could be noted. Unfortunately, no photograph of the oöcyst was taken.

SUSCEPTIBILITY OF L. FUSCANA FOR P. CAPISTRANI

March 3, 1932, one mosquito fed upon bird Y–92; heavily infected with *P. capistrani.* Parasites and red-cell counts on the blood smear are shown in Table 2. On dissection of the stomach, eight and one-half days after the blood meal, eleven oöcysts were counted on both sides of the stomach. Plate 1, fig. 2, shows one oöcyst on the stomach wall. It measured 35 microns at this age. The sporoblastic formation is better observed in fresh specimens.

Two hours later the stomach burst and some of the oöcysts ruptured (Plate 1, fig. 3). Sporozoites in the saline solution along the stomach wall were observed, exhibiting their characteristic movement. They moved sluggishly, forming curves and "s" shapes. The sporozoites were scattered and few could be seen in a field that would insure a good photograph.

SUMMARY AND CONCLUSION

Lutzia fuscana was found to be a vector of *Plasmodium cathemerium* and *P. capistrani.*

Lutzia fuscana has not been reported infected with avian malaria previous to this account.

It is probable that this species may transmit malaria in nature among Philippine birds, if a source of infection is available.

LITERATURE CITED

HUFF, C. G. Studies on infectivity of plasmodia of birds for mosquitoes, with special reference to the problem of immunity in the mosquito. Am. Journ. Hyg. 7 (1927) 706–734.

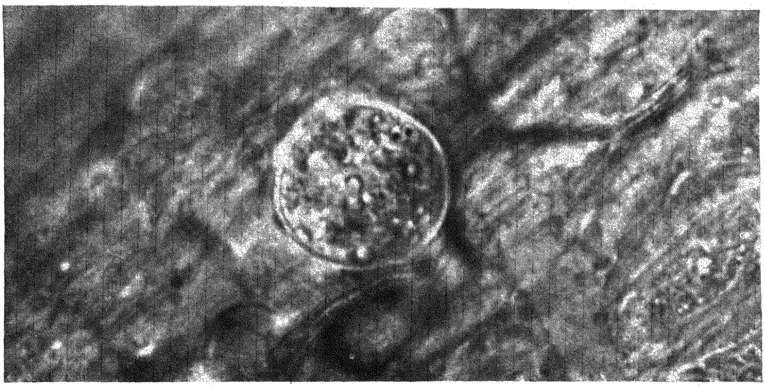
ILLUSTRATION

PLATE 1

FIG. 1. *Plasmodium cathemerium* Hartman, 1924; oöcyst from the stomach wall of *Lutzia fuscana* (Wied.), 33 microns in diameter; protoplasm granular; pigment in clumps and more or less obscured. Six and one-half days old, at room temperature of 31.4° C. and 78.48 average room relative humidity; × 700.

2. *Plasmodium capistrani* Russell, 1932; oöcyst from the stomach wall of *Lutzia fuscana*, 35 microns in diameter; eight and one-half days old, at an average room temperature of 31° C.; × 500.

3. *Plasmodium capistrani;* ruptured oöcyst and an empty capsule from the same stomach in fig. 2. Two sporozoites within the capsule, which have not been released.



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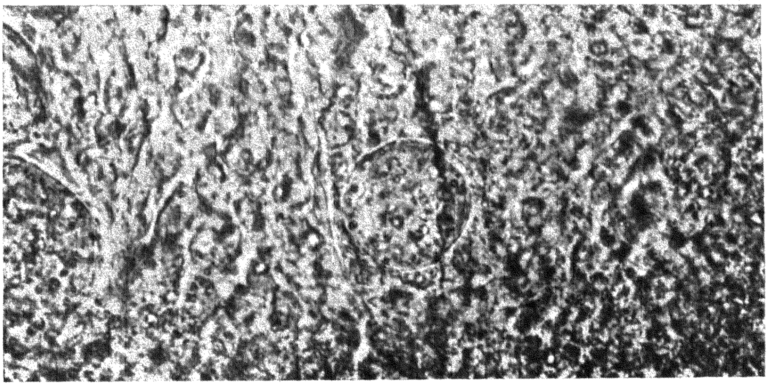

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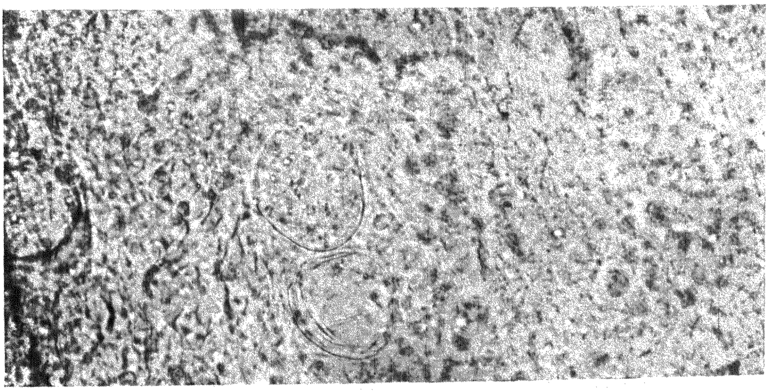

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PLATE 1.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), XVI[1]

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

FOUR PLATES

The present continuation of this series of papers on the tipulid fauna of the Philippines is based on extensive collections made in Tayabas Province, Luzon, by Francisco Rivera, and in Davao district, Mindanao, by Charles F. Clagg. I am very deeply indebted to the collectors of the material, and to Richard C. McGregor, for continued interest in the crane flies of this rich faunal area and for the privilege of retaining in my collection the types of the novelties herein described. Keys to the Philippine species of *Tipula, Epiphragma, Limnophila,* and *Pilaria* are provided.

TIPULINÆ

Genus TIPULA Linnæus

Tipula LINNÆUS, Syst. Nat. ed. 10 (1758) 585.

The known Philippine species of *Tipula* fall within the limits of two well-defined subgenera, *Indotipula* Edwards and *Tipulodina* Enderlein. *Indotipula*[2] is well-represented in the Oriental Region, with fewer species in the adjoining portions of the eastern Palæarctic and Australasian Regions. The subgenus is strongly represented in the Philippines. Previous references made by the present writer to the subgenus *Acutipula* Alexander[3] should be referred to *Indotipula.*

A few characters additional to those given in the original definition by Edwards may be stated. Antennæ 12-segmented, the twelfth segment a mere button; verticils very long; flagellar segments sometimes binodose (*sulaica, angustilobata*). Male hypopygium with the tergite entirely distinct from the sternite-basistyle. Basistyle separated from the sternite by an incomplete suture. Most of the species known to the writer (*manobo* sp. nov. is an exception) have a series of from six to twenty flattened setæ in a single linear row near the outer margin of the inner dististyle. Most of the species have cell M_1 petiolate, as usual in the genus, but a few (*latilobata, manobo, riverai*) have the cell sessile.

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[1] Contribution from the entomological laboratory, Massachusetts State College.

[2] Ann. & Mag. Nat. Hist. X 8 (1931) 81.

[3] Philip. Journ. Sci. 45 (1931) 263.

The Japanese and Chinese species *okinawensis* Alexander, *suensoni* Alexander, and *yamata* Alexander are likewise correctly placed in *Indotipula*. Species in the typical subgenus *Tipula* having similar paired submedian lobes on the ninth tergite differ in having the tergite and sternite-basistyle fused into a continuous ring.

The subgenus *Tipulodina*[4] is well represented in the Philippines by several closely allied species that are most readily separated by details of coloration and structure of the antennæ and male hypopygium. I follow Edwards[5] in placing *Tipulodina* as a subgenus of *Tipula*. The adult flies present few or no decisive characters of generic value, but the nature of the pronotal breathing horns of the pupa in *Tipulodina* indicates that we are here dealing with an isolated group that may require still further consideration as to its strict position when the species are better known. This subgenus is one of the most characteristic in the Oriental Region, with a few additional forms invading the eastern Palæarctic and Ethiopian Regions. The veins of the wing beyond the cord in *Tipulodina* are not entirely devoid of macrotrichia, but veins R_{2+3}, R_{4+5}, and at least the basal portion of R_3 are provided in most species with a nearly complete series of such setæ, the greatest reduction in number being found in species such as *pedata* Wiedemann where only vein R_{4+5} possesses such trichia. In some species, as *mckeani* Cockerell, vein M_1 likewise has macrotrichia throughout its entire length.

The Philippine species of *Tipula* may be separated by means of the accompanying key, which is based in large part on characters of the male sex.

Key to the Philippine species of Tipula Linnæus.

1. Fore tibiæ without spurs; middle tibiæ without, or with but a single spur; legs unvariegated with white; wing tip clear or, if darkened (*fuscoangustata*), the pattern continuous with the stigmal area.
(Subgenus *Indotipula* Edwards.) 2.

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[4] Zoöl. Jahrb. 32 pt. 1 (1912) 30–32.

[5] Ann. & Mag. Nat. Hist. X 8 (1931) 76.

Fore tibiæ with one spur; middle tibiæ with two spurs; legs, in almost all regional species, conspicuously variegated with snowy-white rings (lacking in *deprivata*); wing tip darkened, the area separated from the stigmal darkening. (Subgenus *Tipulodina* Enderlein.) .... 8.

2. Cell M_1 deep, sessile or nearly so (*riverai* group) .... 3.
   Cell M_1 normal, its petiole subequal to m .... 5.
3. Male hypopygium with the lateral lobes of the ninth tergite narrow, separated from one another by a broad U-shaped notch .... 4.
   Male hypopygium with the lateral lobes of the ninth tergite broad, separated from one another only by a narrow linear notch. (Mindanao.) .... *latilobata* sp. nov.
4. Male hypopygium with the median region of the tergal notch produced into a blunt rounded lobe. (Luzon.) .... *riverai* Alexander.
   Male hypopygium without lobe at base of tergal notch. (Mindanao.) *manobo* sp. nov.
5. Wings with cells C and Sc dark brown, this coloration continued around margin to wing apex; a conspicuous dark cloud on anterior cord. (Luzon.) .... *fuscoangustata* Alexander.
   Wings without darkening in outer end of radial cells or on anterior cord .... 6.
6. Antennæ short, the basal flagellar segments bicolorous, yellow, with the enlargements blackened. (Luzon.) .... *ubensis* sp. nov.
   Antennal flagellum uniformly blackened .... 7.
7. Flagellar segments (male) binodose, each segment with a conspicuous distal protuberance, in addition to the basal enlargement. (Mindanao.) .... *angustilobata* sp. nov.
   Flagellar segments (male) simple, without distal protuberance. (Luzon.) .... *ifugao* sp. nov.
8. Wings with a dark spot in cell M at near midlength, more extensive in female and then including also cell R .... 9.
   Wings without such a darkened area .... 11.
9. Basitarsi black, with a clearly defined white ring at near midlength. (Luzon.) .... *cagayanensis* (Alexander).
   Tarsi, including all basitarsi, at most with a nearly obsolete whitish area .... 10.
10. Tibiæ and tarsi entirely blackened. (Mindanao.) *deprivata* sp. nov.
    Tibiæ and tarsi with obscure whitish areas that are poorly delimited, most distinct in female. (Luzon.) .... *succinipennis* (Alexander).
11. Legs with basitarsi black, in cases narrowly tipped with white .... 12.
    Legs with basitarsi black, each with a white ring at near midlength. 13.
12. Wings hyaline, iridescent; Rs relatively long, subequal to R_{2+3}, leaving an extensive clear area between it and stigma. (Luzon.) *luzonica* (Alexander).
    Wings tinged with yellowish; Rs very short, about two-thirds R_{2+3}, practically bordering the inner end of stigma. (Luzon.) *pampangensis* (Alexander).
13. Wings hyaline; mid-basitarsi with white ring; cell 1st M_2 of wings broad, the basal section of vein M^{1+2} more than one-half the second section. (Luzon.) .... *tabuanensis* (Alexander).

Wings with a faint yellowish tinge; mid-basitarsi with the white ring either entirely lacking or barely indicated; cell 1st M_2 of wings narrow, the basal section of M_{1+2} less than one-half the second section. (Luzon.) .... *varitarsis* sp. nov.

The species of *Tipula* in the Philippines, with references to the part of the Philippine series of papers where recorded from the Archipelago, are as follows:

Tipula (*Indotipula*) *angustilobata* sp. nov.; this report.
Tipula (*Indotipula*) *fuscoangustata* Alexander; ALEXANDER, Philippines VI, Philip. Journ. Sci. **41** (1930) 293–294.
Tipula (*Indotipula*) *ifugao* sp. nov.; this report.
Tipula (*Indotipula*) *latilobata* sp. nov.; this report.
Tipula (*Indotipula*) *manobo* sp. nov.; this report.
Tipula (*Indotipula*) *riverai* Alexander; ALEXANDER, Philippines, IV, Philip. Journ. Sci. **33** (1927) 292–293.
Tipula (*Indotipula*) *ubensis* sp. nov.; this report.
Tipula (*Tipulodina*) *cagayanensis* (Alexander); ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 280–281; also, this report.
Tipula (*Tipulodina*) *deprivata* sp. nov.; this report.
Tipula (*Tipulodina*) *luzonica* (Alexander); ALEXANDER, Philippines, II, Philip. Journ. Sci. **27** (1925) 79–81.
Tipula (*Tipulodina*) *pampangensis* (Alexander); ALEXANDER, Philippines, VIII, Philip. Journ. Sci. **45** (1931) 265–266.
Tipula (*Tipulodina*) *succinipennis* (Alexander); ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 279–280.
Tipula (*Tipulodina*) *tabuanensis* (Alexander); ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 277–278.
Tipula (*Tipulodina*) *varitarsis* sp. nov.; this report.

Philippine references to *Tipula* (*Tipulodina*) *cinctipes* de Meijere by Bezzi and to *T.* (*T.*) *pedata* Wiedemann by Osten Sacken, presumably, refer to some one or other of the above-listed species.

TIPULA (INDOTIPULA) LATILOBATA sp. nov. Plate 1, fig. 1; Plate 2, figs. 23, 24.

Belongs to the *riverai* group; mesonotum chiefly yellow, the vague præscutal stripes slightly more orange; flagellar segments with very long verticils; wings grayish subhyaline, cell Sc infuscated, cell C a little less darkened; cell M_1 sessile or nearly so; male hypopygium with the lobes of the ninth tergite very broad, separated from one another only by a linear notch.

Male.—Length, about 14 to 15 millimeters; wing, 15 to 17.5.

Female.—Length, about 20 to 22 millimeters; wing, 18 to 19.

Frontal prolongation of head short, obscure yellow; nasus distinct; palpi obscure yellow. Antennæ 12-segmented; scape and pedicel pale yellow, flagellum black; flagellar segments with long verticils; flagellar segments relatively long and only feebly incised beyond basal enlargement, the apical portion subsinuous (Plate 2, fig. 23); terminal segment very small, about equal in size to the basal enlargement of the other segments. Head above obscure yellow, infuscated medially on vertex.

Mesonotum chiefly yellow, the præscutum with vague indications of more orange stripes. Pleura yellow, immaculate, or with somewhat more orange areas on ventral sternopleurite. Halteres infuscated, the base of stem narrowly paler. Legs with the coxæ and trochanters pale yellow; femora obscure yellow, the tips narrowly blackened; tibiæ brownish yellow, the tips gradually passing into black; tarsi black. Wings (Plate 1, fig. 1) grayish subhyaline, cell Sc infuscated, cell C slightly less darkened; stigma dark brown; very narrow and vague darkenings at wing tip and on anterior cord; veins black. Venation: Cell M_1 very deep, narrowly sessile to very short petiolate.

Abdominal tergites chiefly blackened, including the hypopygium, the basal tergite yellow; basal sternites yellowish. Male hypopygium relatively large, lengthened dorsoventrally, as frequent in the subgenus; tergal region large, extended ventrad, separated from the sternite by an incomplete suture; eighth sternite produced ventrad into a prowlike structure. Median region of tergite (Plate 2, fig. 24, 9*t*) produced into two broad, flattened lobes that are separated from one another only by a linear notch, the apices of the lobes subtruncate to obliquely truncate, densely set with small black spicules. Dististyles (Plate 2, fig. 24, *d*) united at base to an unusual degree, the outer style, *od*, bearing a small glabrous triangular lobule near base; inner style, *id*, of nearly equal size and conformation, short and obtuse, with from seven to nine flattened setæ along outer margin. Notch of ninth sternite with a depressed flattened pale lobe on median line.

MINDANAO, Davao district, Mount Apo (*Clagg*); holotype, male, altitude 6,000 feet, Mainit River, November 15, 1930; allotype, female, altitude 6,500 feet, Mainit River, September 14, 1930; paratypes, altitude 6,000 feet, September 3 and 4, October 12, and November 5, 1930; altitude 6,500 feet, September 5 to 10, 1930; altitude 8,000 feet, September 16, 1930.

The sessile or subsessile cell M_1 of the wings suffices to separate this fly from all allied regional species, excepting *manobo* sp. nov. and *riverai* Alexander, which are readily distinguished by means of the hypopygial characters listed in the key.

TIPULA (INDOTIPULA) MANOBO sp. nov. Plate 2, fig. 25.

Belongs to the *riverai* group; size small (wing, male, 14 millimeters); mesonotum yellow to yellowish orange; legs black; wings grayish subhyaline, cell Sc and the stigma dark brown; male hypopygium with the tergite produced into two lobes that are separated by a broad U-shaped notch; outer dististyle with two weak denticles on inner margin; no flattened setæ arranged in a single definite row on outer margin of inner dististyle.

Male.—Length, about 12 millimeters; wing, 14.

Frontal prolongation of head yellowish brown; nasus conspicuous; palpi pale brown. Antennæ with the scape and pedicel yellow to brownish yellow; flagellum black, the extreme base of the first segment pale; flagellar segments simple, the verticils exceeding the segments. Head yellowish brown to brown, with a faintly indicated median brown vitta.

Mesonotum yellow, the præscutum with scarcely defined orange-yellow stripes. Pleura orange-yellow. Halteres pale, the knobs dark brown. Legs with the coxæ and trochanters yellow; remainder of legs black, the femoral bases restrictedly paler. Wings grayish subhyaline, cell Sc and stigma dark brown; veins brownish black. Venation: Cell M_1 sessile.

Basal abdominal tergites orange-yellow, the outer segments, including the hypopygium, black; in some cases, the lateral margins of the intermediate tergites are conspicuously darkened; basal sternites obscure yellow. Male hypopygium with the caudal margin of tergite (Plate 2, fig. 25, 9*t*) bearing two lobes that are separated by a broad U-shaped notch, the lobes blackened and microscopically spiculose at apex; viewed from above, these lobes appear relatively narrow, viewed laterally they are much higher. Outer dististyle (Plate 2, fig. 25, *od*) flattened, strongly narrowed on distal third, more strongly and abruptly so in the holotype than in the paratype figured; outer margin with coarse spinous setæ, arranged in groups of twos or threes, the inner margin with two obtuse denticulate lobules. Inner dististyle (Plate 2, fig. 25, *id*) relatively short and broad, the posterior and outer margin with numerous coarse setæ but these neither flattened nor arranged in a linear marginal series, as is the case in many other species of the subgenus.

MINDANAO, Davao district, Mount Apo (*Clagg*); holotype, male, altitude 7,000 feet, Seliban River, September 11, 1930; paratopotype, male, with type; paratype, male, altitude 6,000 feet, Galog River, October 22, 1930.

Tipula (*Indotipula*) *manobo* is named from one of the native tribes inhabiting the environs of Mount Apo. The nearest described ally seems to be *T.* (*I.*) *riverai* Alexander (Luzon), which is most readily separated by the genitalic characters given in the key.

TIPULA (INDOTIPULA) UBENSIS sp. nov. Plate 2, fig. 26.

Belongs to the *walkeri* group; general coloration of mesonotal præscutum olive-brown, the lateral margins broadly buffy yellow; antennæ short, bicolorous; wings with a strong brown tinge, cells C and Sc more saturated brown; Rs about one-half longer than R_{2+3}; male hypopygium with the lobes of the tergite broad, obliquely truncated, nearly contiguous on median line.

Male.—Length, about 12 millimeters; wing, 13.

Female.—Length, about 17 millimeters; wing, 14.

Frontal prolongation of head light brown, the lateral portions darker brown; nasus long and conspicuous; palpi pale, the terminal segment black. Antennæ (male) relatively short, if bent backward ending before the wing root; scape and pedicel brownish yellow; basal flagellar segments bicolorous, the enlargement black, the remainder light yellow; color of fifth and succeeding flagellar segments more uniformly darkened; flagellar segments simple. Head dark brown, more grayish on front and on anterior vertex, behind with a capillary darkened median vitta.

Mesonotal præscutum with the disk almost covered by three nearly confluent olive-brown stripes, the posterior interspaces being very narrow and restricted; lateral margins of sclerite abruptly and broadly buffy yellow; scutum pale, the lobes largely covered by pale brown areas; scutellum and postnotum pale brown, the latter variegated on sides by yellow. Pleura buffy yellow, variegated with brown on anterior anepisternum, ventral sternopleurite, and ventral meron. Halteres yellow, the knobs infuscated. Legs with the coxæ pale buffy, the fore and middle coxæ more infuscated; trochanters yellow; femora yellow, the tips narrowly dark brown; tibiæ and tarsi yellow, the terminal tarsal segments darkened. Wings with a strong brown tinge, the base and cubital region more yellowish, cells C and Sc, with the stigma, more saturated brown; veins light brown. Macrotrichia on veins R_3, R_{4+5}, and M_1. Venation: Rs relatively long, about one-half to two-thirds longer than R_{2+3}; petiole of cell M_1 subequal to or longer than m.

Abdominal tergites obscure yellow, margined laterally and caudally with brown, the outer segments more uniformly darkened; sternites more uniformly yellow. Male hypopygium with the tergite (Plate 2, fig. 26, 9*t*) very extensive, the lobes broad, obliquely truncated, set with sparse blackened spicules and coarse setæ; lobes separated on midline only by a linear notch. Outer dististyle (Plate 2, fig. 26, *od*) broad, narrowed at apex into a slender portion; caudal margin of style before point of narrowing with numerous setæ that are longer than elsewhere on surface. Inner dististyle (Plate 2, fig. 26, *id*) broad, the flattened setæ along outer margin about twelve in number.

LUZON, Laguna Province, Ube (*Rivera*); holotype, male; paratypes, 2 males; Tayabas Province, Lucban, altitude, 1,400 feet, January 24, 1931 (*Rivera*); allotype, female.

Tipula (*Indotipula*) *ubensis* is very different from the remaining Philippine species of the subgenus, the short, bicolorous antennæ and structure of the male hypopygium, readily sufficing to define the species. It is more similar and allied to the Japanese and Chinese members of the subgenus that center about *T.* (*I.*) *yamata* Alexander.

TIPULA (INDOTIPULA) IFUGAO sp. nov. Plate 2, fig. 27.

Belongs to the *walkeri* group; antennal flagellum black throughout; petiole of cell M_1 exceeding one-half m; male hypopygium with two obtuse blackened lobes that are separated from one another by a V-shaped notch; inner dististyle complex in structure.

Male—Length, about 13 millimeters; wings, 14.5.

Frontal prolongation of head light ocherous; nasus very long; palpi pale, the terminal segment darker. Antennæ with the scape and pedicel yellow, flagellum black; flagellar segments unusually long, simple, the verticils exceeding the segments. Head gray, the front and occiput more yellowish; a capillary blackish median line.

Mesonotum brownish ocherous, the præscutal stripes only poorly defined. Pleura light yellow, scarcely variegated with darker. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters pale yellow; femora yellowish brown to light brown, their tips darkened; remainder of legs passing into black. Wings subhyaline, cell C faintly darkened, cell Sc and stigma dark brown; veins brownish black. Venation: Rs subequal to R_{2+3}; petiole of cell M_1 exceeding one-half m.

Basal abdominal tergites yellow, the outer segments more infuscated, their extreme caudal margins pale; sternites more yellowish. Male hypopygium with the tergite produced into two cylindrical blackened lobes that are separated only by a narrow V-shaped notch, their tips obtuse. Outer dististyle (Plate 2, fig. 27, *od*) gradually narrowed outwardly, with numerous, chiefly marginal setæ. Inner dististyle, *id*, a complex structure, as shown (Plate 2, fig. 27), the outer portion bearing a slender blackened spine.

LUZON, Mountain Province, Ifugao Subprovince, Hungduan, April 5, 1930 (*Rivera*); holotype, male.

The specific name, *ifugao*, is that of a tribe of mountain people of northern Luzon. The species is quite distinct from the other regional species of *Indotipula* in the structure of the ninth tergite and inner dististyle of the male hypopygium.

TIPULA (INDOTIPULA) ANGUSTILOBATA sp. nov. Plate 1, fig. 2; Plate 2, figs. 28, 29.

Belongs to the *sulaica* group; size large (wing, male, over 17 millimeters); antennal flagellum black, the segments conspicuously binodose, the basal enlargement with very long verticils; wings with a strong brownish yellow tinge; cell M_1 with its petiole subequal to m; male hypopygium with the two lobes of the tergite blackened, narrowed outwardly into slender spiculose points, the surface of the lobes with abundant coarse setæ.

Male.—Length, about 16 to 17 millimeters; wing, 18 to 20.

Frontal prolongation of head yellow above, darkened laterally; nasus long and conspicuous; basal three segments of palpi obscure yellow, the terminal segment a trifle darker. Antennæ (Plate 2, fig. 28) with the scape, pedicel, and base of first flagellar segment yellow; remainder of organ black, 12-segmented; flagellar segments beyond the first conspicuously binodose, as in *sulaica;* verticils very long and conspicuous. Head brownish gray, the median area and spots caudad of the antennal fossæ more blackened.

Mesonotal præscutum buffy, almost covered by four, dark fulvous-brown stripes, these in cases narrowly bordered by still darker brown; scutal lobes obscure yellow, each with two dark fulvous-brown areas; scutellum yellowish testaceous, with a faint brown median vitta; postnotum yellowish brown. Pleura yellow, vaguely variegated on anepisternum, ventral sternopleurite and meron with more reddish brown. Halteres brown, the base of stem restrictedly paler. Legs with the coxæ and trochanters yellow; femora brownish yellow, the tips narrowly dark brown; tibiæ brown, the tips narrowly blackened; tarsi black. Wings (Plate 1, fig. 2) with a strong brownish yellow tinge, cell Sc more brownish, cell C more yellowish; stigma yellowish brown; veins dark brown. Venation: Cell M_1 with the petiole variable in length, from about three-fourths to longer than m.

Abdominal tergites dark brown, the outer segments passing into black, the basal tergite more reddish brown; caudal and lateral margins of segments narrowly pale; basal sternites reddish brown, the outer segments more blackened. Male hypopygium with the tergite (Plate 2, fig. 29, 9*t*) bearing two triangular blackened lobes on either side of midline, these narrowed into slender points that are tipped with weak blunt spinules; surface of lobes with numerous coarse setæ. Outer dististyle (Plate 2, fig. 29, *od*) elongate, gradually widened outwardly, the posterior margin with numerous setæ. Inner dististyle (Plate 2, fig. 29, *id*) with about twenty flattened setæ in a row along outer margin.

MINDANAO, Davao district, Mount Apo (*Clagg*); holotype, male, altitude 7,000 feet, Baroring River, November 9, 1930; paratopotypes, 2 males, November 8 and 9, 1930; paratypes, 1 male, altitude 6,500 feet, Seliban River, September 11, 1930; 1 male, Taloon trail, Santa Cruz Mountain, altitude 3,000 to 5,000 feet, September 13, 1930; 1 male, La Lun Mountains, altitude 5,500 feet, January 2, 1931.

Tipula (*Indotipula*) *angustilobata* is most nearly allied to *T.* (*I.*) *sulaica* (Walker) Edwards, which is known to me only by the brief note and figure by Edwards.[6] If this species was actually described by Walker, it has been overlooked by all recent cataloguers of the Oriental Diptera (Kertész, Brunetti, Pierre); if not described, the name should be credited to Edwards on the basis of the above reference. The Walker type was from Sula Island, east of Celebes, while the material considered by Edwards as being conspecific was from Borneo. Edwards compares *sulaica* with *T.* (*I.*) *gedehicola* Alexander (Java), indicating the approximate similarity of the male hypopygium. The fly above described has a very different hypopygium, shown most evidently in the narrowly pointed lobes of the ninth tergite and the distinct conformation of both dististyles. The fly is one of the largest species of the subgenus so far made known. The peculiar binodose flagellar segments are much as in *sulaica* and may well occur in other still undiscovered species in the Malayan Islands.

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[6] Sarawak Mus. Journ. 3 (1926) 277, pl. 10, fig. 46.

TIPULA (TIPULODINA) CAGAYANENSIS (Alexander).

Tipulodina cagayanensis ALEXANDER, Philip. Journ. Sci. **43** (1930) 280–282.

The types were from Mount Tabuan, Cagayan Province, Luzon. A male and a female were taken by Rivera at Lucban, Tayabas Province, Luzon, January 23 to 26, 1931. The antennæ of the male sex are notably shorter than in *luzonica* (Alexander). The darkened area in the basal cells of wing is restricted to cell M in the male, while being much larger and including both cells R and M in the female.

TIPULA (TIPULODINA) VARITARSIS sp. nov. Plate 1, fig. 3; Plate 2, fig. 30.

Male.—Length, about 13 to 14 millimeters; wing, 14.5 to 17.

Most similar to *T.* (*T.*) *tabuanensis* (Alexander), differing in the details of coloration and venation. Palpi dark, the second segment, base of third and distal half of fourth pale. Antennæ (male) elongate, if bent backward extending about to base of second abdominal segment; flagellar segments black, the extreme incisures pale. Middle legs with the basitarsi entirely blackened or with only vague suggestions of a pale annulus. Wings (Plate 1, fig. 3) with a pale yellow tinge; dark pattern much as in *tabuanensis* but the seams along cord and veins of outer medial field more extensive and continuous. Venation: Rs longer and cell 1st M_2 narrower than in *tabuanensis*, the first section of vein M_{1+2} being about two-fifths the second section; in *tabuanensis* this element is about three-fifths the second. Abdomen with the blackened subterminal rings even, not produced cephalad medially, as is the case in some of the other species of the subgenus. Male hypopygium (Plate 2, fig. 30) with the outer dististyle, *od*, blackened only at extreme apex, the remainder densely setiferous, especially a dense fringe along outer margin.

LUZON, Tayabas Province, Lucban (*Rivera*); holotype, male, January 26, 1931; paratypes, 3 males, January 25 and 26, 1931.

TIPULA (TIPULODINA) DEPRIVATA sp. nov. Plate 1, fig. 4.

Female.—Length, about 25 millimeters; wing, 20.

Closely allied to *T.* (*T.*) *succinipennis*, differing as follows: Palpi with terminal segment entirely pale. Mesonotal præscutum with the ground color yellow, the four usual stripes olive-brown, but little distinct against the ground, their margins a little darker; postnotal mediotergite almost covered by a dark brown central portion. Legs (only a middle leg remains) with the femora yellow, the tips conspicuously blackened, without subterminal brightening; tibiæ and tarsi dark brown to brownish black, with no indication of paler annuli. Wings (Plate 1, fig. 4) with the ground color much paler yellow than in *succinipennis* but still not of the iridescent hyaline clearness of other Philippine species; dark area in cells R and M including both cells; cell Sc, cord, outer end of cell 1st M_2, veins of outer medial field and wing tip in radial field brown; stigma relatively large, its cephalic-proximal portion lying above vein $Sc_2 + R_1$ pale yellow. Trichiation of veins as in *succinipennis*, being found on R_{4+5} and basal half of R_3. Venation: Rs subequal to R_{2+3}; cell R_3 at margin more extensive than cell R_2; outer medial and cubital cells deep. Abdominal tergites chiefly dark brown, the basal rings buffy; lateral margins grayish brown; an interrupted brownish black dorsomedian vitta.

MINDANAO, Davao district, Mount Apo, Sibulan River, altitude 5,000 to 6,000 feet, October 20, 1930 (*Clagg*); holotype, female.

The present fly is most nearly allied to *T.* (*T.*) *succinipennis* (Alexander) among the described Philippine species, differing in the pattern of the mesonotum and in the entirely unbanded legs. The yellow tinting of the wings is intermediate in degree between that of the amber-colored wings of *succinipennis* and the usual crystal-clear wings of the commoner Philippine species. The fly is likewise allied to *T.* (*T.*) *albiprivata* Edwards (Borneo), which differs in the distinct coloration of the thorax, together with the nearly hyaline ground color of the wings, with a slightly different pattern.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) CAPELLA sp. nov. Plate 1, fig. 5; Plate 2, fig. 31.

Belongs to the *albitarsis* group; general coloration of mesonotum dark brown; tarsi extensively snowy white; wings with a strong brown suffusion, the cord and outer end of cell 1st M_2 narrowly seamed with darker; male hypopygium with the dorsal dististyle a slender blackened rod; rostral spine long and slender, arising from a long basal tubercle that is fully one-third as long as the spine itself.

Male.—Length, about 5 millimeters; wing, 6.2.

Rostrum and palpi black. Antennæ black throughout; flagellar segments with short apical necks; longest verticils about one-half longer than the segments; terminal segment elongate. Head dark brown.

Mesonotum uniformly dark brown. Pleura with the dorsal sclerites brownish black, the ventral sternopleurite dark brown, the dorsal sternopleurite a little brightened. Halteres black, the extreme base of stem obscure yellow. Legs with the coxæ brown, the fore coxæ somewhat darker; trochanters brownish yellow; femora and tibiæ black; tarsi white, on middle legs the basitarsi with a little more than the proximal four-fifths blackened; fore and hind legs broken; claws elongate, with a long basal spine on lower face and a much smaller appressed spinule at near midlength. Wings (Plate 1, fig. 5) with a strong brown suffusion, the costal region somewhat more saturated; a narrow stigmal seam and poorly indicated clouds along cord and outer end of cell 1st M_2 darker brown; veins dark brown. Venation: Sc_1 ending about opposite three-fourths the length of Rs, Sc_2 some distance from its tip; free tip of Sc_2 and R_2 in approximate transverse alignment; m-cu just beyond the fork of M; vein 2d A converging strongly toward 1st A.

Abdomen black, the caudal margins of the individual segments paler; eighth segment pale; hypopygium dark. Male hypopygium (Plate 2, fig. 31) with the ninth tergite, *9t*, transverse, the caudal margin gently emarginate. Basistyle, *b*, elongate, the ventromesal lobe basal in position, bearing a slender clavate extension. Dorsal dististyle a slender, nearly straight, blackened rod. Ventral dististyle, *vd*, oval, the rostral spine very long and slender, from an enlarged basal tubercle that is fully one-third as long as the spine itself. Gonapophyses, *g*, with the mesal-apical lobe stout. Ædeagus, *a*, with the apex simple.

MINDANAO, Davao district, Mount Apo, Galog River, altitude 6,000 feet, October 21, 1930 (*Clagg*); holotype, male.

Limonia (*Limonia*) *capella* is quite distinct from the allied *L.* (*L.*) *subalbitarsis* Alexander (Luzon) in the small size and distinct male hypopygium, especially the long basal tubercle of the rostral spine, the slender dorsal dististyle, and the simple apex of the ædeagus.

LIMONIA (LIMONIA) BRACHYNEURA sp. nov. Plate 1, fig. 6; Plate 2, fig. 32.

Closely allied to *calianensis;* general coloration orange, the mesonotum with two narrow, dark brown, nearly parallel stripes extending from midlength of the præscutum to the base of abdomen; pleura with a broad dark brown longitudinal stripe; wings strongly tinged with blackish; Sc relatively short, ending about opposite one-third the length of Rs; male hypopygium with the two rostral spines placed close together on the actual face of style, their bases completely encircled by microscopic setulæ.

Male.—Length, about 3.6 millimeters; wing, 4.

Mouth parts greatly reduced in size, black. Antennæ black throughout; flagellar segments oval, the outer segments becoming more slender and elongate; terminal segment elongate, subequal to the penultimate; verticils very long and conspicuous, especially on the outer segments, chiefly unilaterally arranged. Head orange; anterior vertex very broad.

Pronotum yellow, blackened on sides. Mesonotum with the præscutum chiefly covered by three orange-yellow stripes that are confluent in front, the dark brown interspaces represented by conspicuous lateral margins and posterior intermediate lines, the latter continued caudal, crossing the scutal lobes, scutellum, and postnotal mediotergite, nearly parallel or but gently converging at the abdomen. Pleura light yellow, traversed by a broad, dark brown, longitudinal stripe. Halteres brownish black, the base of stem narrowly brightened. Legs with the coxæ and trochanters pale yellow; remainder of legs black, the femoral bases restrictedly brightened; claws slender, with a long erect basal spine and a more-appressed lateral spine at midlength. Wings (Plate 1, fig. 6) strongly tinged with blackish; very vague, slightly darker seams along cord and outer end of cell 1st M_2; stigma appearing as a narrow seam on R_2; veins slightly darker. Venation: Sc short, Sc_1 ending about opposite one-third to one-fourth the length of Rs, Sc_2 at its tip; m-cu more than one-half its length beyond the fork of M.

Abdominal tergites dark brown; basal sternites yellow, the outer segments dark brown with their caudal margins narrowly yellow. Male hypopygium (Plate 2, fig. 32) with the tergite, *9t,* transverse, its caudal margin weakly emarginate. Dorsal dististyle glabrous. Rostral prolongation of ventral dististyle, *vd,* elongate, slightly bent at beyond midlength; rostral spines placed on face of style and not at the base of the prolongation, as in *calianensis,* their fossæ being entirely surrounded by microscopic setulæ. Gonapophyses, *g,* elongate, pale, as in *calianensis.*

LUZON, Tayabas Province, Lucban, January 24, 1931 (*Rivera*); holotype, male.

Limonia (*Limonia*) *brachyneura* is allied to *L.* (*L.*) *calianensis* Alexander (Luzon, Mindanao), differing especially in the short subcosta and the slightly different male hypopygium, notably the basal position of the insertion of the rostral spines.

LIMONIA (LIMONIA) BROWNI sp. nov. Plate 1, fig. 7; Plate 3, fig. 33.

Allied to *Limonia ligayai;* general coloration of mesonotal præscutum brownish black, obscure yellow sublaterally; antennal segments (male) not pedicellate apically; tibiæ and tarsi conspicuously paler than the femora; wings dusky, the stigma darker brown; male hypopygium with the gonapophyses very broad, the mesal-apical angle an acute spine.

Male.—Length, about 4 millimeters; wing, 4.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval to subcylindrical, without glabrous apical necks; verticils subequal in length to the segments; terminal segment a little exceeding the penultimate, at apex narrowed to a button. Head blackish, the narrow anterior vertex slightly pruinose.

Mesonotal præscutum with the ground color obscure yellow, the dorsum almost covered by three confluent brownish black stripes; lateral margins of præscutum behind the pseudosutural foveæ narrowly infuscated; posterior sclerites of mesonotum blackened. Pleura obscure yellow, traversed by a narrow, black, longitudinal stripe that passes beneath the root of the halteres, the latter black with the base of the stem narrowly but conspicuously yellow. Legs with the coxæ and trochanters obscure yellow; femora black; tibiæ yellowish brown, the bases of fore and middle tibiæ more infuscated, the tips of all tibiæ very narrowly and insensibly darkened; tarsi obscure yellow, the outer segments darkened; claws small, with about three slender spines at base, the outermost largest, the more basal ones setiform. Wings (Plate 1, fig. 7) with a dusky tinge, the costal region darker; stigma short-oval, brown; veins dark brown. Venation: Sc_1 ending about opposite midlength of Rs, Sc_2 not far from its tip; m-cu just beyond fork of M.

Abdominal tergites black, the basal sternites more yellowish brown; hypopygium dark. Male hypopygium (Plate 3, fig. 33) with the tergite, *9t*, transverse, narrowed outwardly, the caudal portion weakly emarginate. Dorsal dististyle, *dd*, a long, curved, acutely pointed rod, its surface with long delicate setulæ. Rostral prolongation of ventral dististyle, *vd*, elongate, the two spines at its base. Gonapophyses, *g*, very broad, the mesal-apical angle a short, acute, curved spine, the margin of the apophysis adjoining this spine provided with microscopic serrulations. Ædeagus, *a*, deeply notched at apex.

LUZON, Tayabas Province, Lucban, January 26, 1931 (*Rivera*); holotype, male; paratype, male.

Limonia (*Limonia*) *browni* is named in honor of Director William H. Brown, of the Philippine Bureau of Science, to whom I express my indebtedness for coöperation in making known the extensive tipulid fauna of the Islands. The fly is most nearly allied to *L.* (*L.*) *ligayai* Alexander (Luzon, Mindanao) in the setiferous outer dististyle and structure of the inner dististyle of the male hypopygium, differing conspicuously in the nonpedicellate flagellar segments and in the very differently constructed gonapophyses and narrow tergite of the hypopygium.

LIMONIA (DICRANOMYIA) SUBORTHIA sp. nov. Plate 1, fig. 8; Plate 3, fig. 34.

General coloration of thorax gray, the præscutum with a median dark brown stripe; knobs of halteres orange; femora yellow, with a narrow, dark brown, subterminal ring; wings with costal fringe (male) long and conspicuous; disk cream-colored with a heavy brown pattern that is chiefly costal but includes large darkened areas at ends of both anal veins; abdominal segments dark brown, their caudal margins broadly yellow.

Male.—Length, 4.2 to 4.5 millimeters; wing, 5 to 5.5.

Female.—Length, about 5 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ black; scape more or less pruinose; flagellar segments oval; verticils short, subequal to the segment. Head brownish gray.

Mesonotal præscutum gray with a median dark brown stripe; scutal lobes similarly darkened; posterior sclerites of mesonotum dark gray. Pleura dark gray, more or less variegated by blackish areas. Halteres testaceous, the knobs orange. Legs with the fore coxæ blackened, the remaining coxæ somewhat paler; trochanters yellow; femora yellow, with a narrow dark brown subterminal ring; tibiæ brownish yellow, the tips narrowly darkened; tarsi brownish yellow, the outer segments darker. Wings (Plate 1, fig. 8) cream-colored, heavily patterned with brown, including a series of about five areas in the costal region, the fourth, largest, being the stigma; smaller marginal clouds at ends of medial and cubital veins, with large conspicuous areas at ends of both anal veins; cord and outer end of cell 1st M_2 narrowly seamed with brown; veins pale, darker in the infuscated areas. Costal fringe (male) long and conspicuous. Venation Sc_1 ending opposite or shortly beyond the origin of Rs, Sc_2 far from its tip, being placed in the second dark costal area; m-cu close to fork of M, subequal to or longer than the distal section of Cu_1; cell 2d A wide.

Abdomen dark brown, the caudal margins of the segments conspicuously ringed with obscure yellow; hypopygium reddish brown, especially the ventral dististyle. Male hypopygium (Plate 3, fig. 34) with the basistyle, *b*, small, with its ventral-mesal lobe large. Ventral dististyle, *vd*, large and fleshy, the rostral prolongation small, with two short spines that are placed close together. Dorsal dististyle a very strongly curved hook, the extreme tip gently upcurved.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet (*Clagg*); holotype, male, January 28, 1931; allotype, female, January 30, 1931; paratopotypes, 8 males and females, January 28 to 30, 1931; paratype, 1 male, Calian, La Lun Mountains, altitude 5,500 feet, December 29, 1931 (*Clagg*).

Although closely allied to *Limonia* (*Dicranomyia*) *orthia* Alexander (Luzon), the present species is clearly distinct in the entirely different pattern of the legs and in the long, erect costal fringe in the male sex. The paratype male from the La Lun Mountains has the costal fringe short but with the leg pattern as in *suborthia* and is here considered as belonging to the present species, although the possibility exists that there is still another closely allied species or race involved.

LIMONIA (DICRANOMYIA) ORTHIOIDES sp. nov. Plate 1, fig. 9.

Allied to *orthia;* mesonotum brown, sparsely pollinose, the præscutum without distinct markings; knobs of halteres infuscated; legs dark brown; wings pale grayish, with a restricted dark costal pattern; cell 1st M_2 tending to be open by the atrophy of m.

Male.—Length, about 4.5 millimeters; wing, 5.3.

Female.—Length, about 4.8 millimeters; wing, 5.2.

Rostrum, palpi, and antennæ black; basal flagellar segment longer than the second; intermediate segments short-oval, the outer segments more elongate; terminal segment a little exceeding the penultimate; longest verticils of basal and intermediate flagellar segments about one-half longer than the segments alone. Head light gray, more infuscated medially behind.

Mesonotum brown, with a sparse yellow pollen, the præscutum without distinct stripes; scutal lobes conspicuously darkened; posterior sclerites of mesonotum dark brown, sparsely pruinose. Pleura pale, the anepisternum and ventral sternopleurite variegated with darker. Halteres pale, the knobs infuscated. Legs with the fore coxæ dark brown, the remaining coxæ paler; trochanters obscure yellow; remainder of legs dark brown, the femoral bases restrictedly pale. Wings (Plate 1, fig. 9) with a grayish tinge, the prearcular region somewhat paler; a restricted dark costal pattern, including small darkened areas above arculus, at Sc_2, and at tip of Sc_1; stigmal area larger; no distinct cloudings elsewhere on membrane. Venation: Sc_1 ending opposite origin of Rs, Sc_2 far before its tip, at near mid-distance between arculus and tip of Sc_1; cell 1st M_2 tending to be open by the atrophy of m; m-cu close to fork of M; cell 2d A wide.

Abdomen dark brown, the eighth segment paler; caudal margins of the individual segments slightly paler. Male hypopygium much as in *orthia* and *suborthia*.

MINDANAO, Davao district, Mount Apo, Sibulan River, altitude 7,000 to 8,000 feet, September 21, 1930 (*Clagg*); holotype, male; allotype, female.

Limonia (*Dicranomyia*) *orthioides* is readily told from both *L.* (*D.*) *orthia* Alexander (Luzon) and *L.* (*D.*) *suborthia* sp. nov. (Mindanao) in the slightly patterned wings, with cell 1st M_2 tending to be open by the atrophy of m. It is further told from *suborthia* by the infuscated knobs of the halteres, the dark brown legs, and the short costal fringe of the male sex. Cell 1st M_2 is entirely open on both wings of the allotype and partly open on one wing of the holotype.

LIMONIA (RHIPIDIA) SERVILIS sp. nov. Plate 1, fig. 10; Plate 3, fig. 35.

Belongs to the *maculata* group; antennæ (male) with six bipectinate flagellar segments; median præscutal stripe entire or nearly so; knobs of halteres dark brown; wings creamy white, with an abundant brown and gray spotted and clouded pattern, the gray areas abundant and confluent; Sc_1 ending about opposite midlength of Rs; m-cu shortly before the fork of M; male hypopygium with four rostral spines.

Male.—Length, about 5 millimeters; wing, 5.7.

Female.—Length, about 5.5 millimeters; wing, 5.6.

Rostrum and palpi brownish black. Antennæ (male) with the scape, pedicel, and flagellar branches brownish black, the long apical pedicels of all branched segments whitish; flagellar segments 2 to 7 each with two branches, the longest about one-half longer than the segment itself; eighth flagellar segment with a single branch that is subequal to the segment itself; remaining flagellar segments simple. Antennæ (female) with the basal flagellar segments produced on ventral face. Head blackish gray; anterior vertex narrow.

Mesonotal præscutum covered with a yellowish pollen, leaving a broad, entire, dark brown or black, median area and narrower, less distinct, lateral stripes; scutal lobes darkened; scutellum and postnotum dark brown, sparsely pruinose. Pleura brownish gray, narrowly striped longitudinally with darker. Halteres pale, the knobs dark brown. Legs with the coxæ dark; trochanters obscure yellow; remainder of legs dark brown, the femoral bases slightly paler; in male, the femora more yellowish brown, the tips darkened. Wings (Plate 1, fig. 10) with the ground color creamy white, the costal region more yellowish; a heavy brown and gray spotted and clouded pattern, the darker areas being costal in position, five or six in number, the fifth being at stigma, the third and fourth areas, at origin of Rs and tip of Sc, separate; all gray areas more or less confluent and chiefly obscuring the ground color; veins brown, paler in the costal interspaces. Costal fringe relatively long, especially in male. Venation: Sc_1 ending at near midlength of Rs, Sc_2 at its tip; m-cu shortly before fork of M.

Abdomen dark brown; hypopygium paler. Male hypopygium (Plate 3, fig. 35) with the rostral prolongation of the ventral dististyle, *vd*, relatively long, with four spines that are directed basad at their tips, arising from a close group at near two-thirds the length of the prolongation.

MINDANAO, Davao district, La Lun Mountains, altitude 5,500 feet, December 31, 1930 (*Clagg*); holotype, male; allotype, female.

Limonia (*Rhipidia*) *servilis* is closely allied to several other regional species of the *maculata* group in the Malayan fauna, especially *L.* (*R.*) *griseipennis* (Edwards) of Borneo, *L.* (*R.*) *javanensis* (de Meijere) of Java, and *L.* (*R.*) *triarmata* Alexander of Formosa. From the last two it differs in the presence of only six branched flagellar segments in the male and in the armature of the male hypopygium, especially the number of rostral spines. The male sex of *griseipennis* has not been fully described. The present fly differs from it most evidently in the entire median præscutal stripe and the uniformly darkened knobs of the halteres.

LIMONIA (EUGLOCHINA) CAPTIOSA sp. nov. Plate 1, fig. 11.

Size large (wing, male, 8.5 millimeters or more); proximal ends of basitarsi extensively blackened, including approximately two-thirds the total length of the segment; wings with Rs not contiguous to the proximal end of stigma; male hypopygium with the ventral dististyle very large, oval.

Male.—Length, about 8 to 9 millimeters; wing, 8.5 to 11.

Female.—Length, about 8 to 9 millimeters; wing, 8 to 9.

Rostrum, palpi, and antennæ black; flagellar segments elongate-oval, with short glabrous apical necks and long, secund verticils that are approximately twice as long as the segments. Head brownish black.

Pronotum and mesonotal præscutum brownish black medially, obscure yellow laterally; scutal lobes extensively brownish black; posterior sclerites of mesonotum more yellowish. Pleura brownish yellow. Halteres elongate, pale brown, the knobs darker. Legs with the coxæ, trochanters, and bases of femora pale yellow, the remainder of femora, all tibiæ, and proximal ends of basitarsi black; remainder of tarsi snowy white; the amount of blackening on basitarsi slightly variable, including about the proximal two-thirds of the segment. Wings (Plate 1, fig. 11) with a brownish tinge, the oval stigma darker brown; veins brownish black. Venation: Sc relatively long, the space on Sc between the tip of Sc_1 and origin of Rs less than twice the length of the stigma; Rs angularly bent at near midlength, not lying contiguous to the proximal end of stigma, as in *arachnobia, cuneiformis,* and other species; basal section of R_{4+5} angularly bent before midlength; vein 2d A long, ending opposite or just before the level of tip of Sc_1.

Abdominal tergites brownish black; basal sternites more yellowish; hypopygium dark. Male hypopygium with the ventral dististyle unusually large, oval in shape.

MINDANAO, Davao district, Mount Apo (*Clagg*); holotype, male; allotype, female, Mainit River, altitude 6,500 feet, September 10, 1930; paratopotypes, 2 males; paratypes, 1 female, Mainit River, altitude 6,000 feet, September 4, 1930; 1 male, 2 females, Kidopawan train from Lake Lino, altitude 7,000 to 8,000 feet, September 20 and 21, 1930; 1 male, 1 female, Baroring River, altitude 7,000 feet, November 8, 1930; 1 male, Bawook Falls, Sibulan River, altitude 2,000 feet, November 13, 1930; 1 male, 2 females, La Lun Mountains, altitude 5,000 feet, January 1, 1931.

In its large size and venation, *Limonia* (*Euglochina*) *captiosa* is similar to *L.* (*E.*) *dignitosa* Alexander (western China), differing in the extensive blackened proximal ends of the basitarsi. The fly differs from *L.* (*E.*) *arachnobia* Alexander (Philippines) in the large size, details of venation, as the relation of Rs to the proximal end of stigma, and the large oval ventral dististyle of the male hypopygium. There appear to be several species of *Euglochina* in the Malayan Region that are very difficult of separation, the male hypopygium being generally similar in all species, leaving the chief characters for separation in the size, the venation, especially the relative length of Sc and the length and position of Rs, and the presence and degree of blackening of the basitarsi of all legs.

LIMONIA (PSEUDOGLOCHINA) BILATIOR sp. nov. Plate 1, fig. 12.

General coloration of mesonotal præscutum chestnut-brown; thoracic pleura yellow dorsally, brown on ventral sclerites; tibiæ and tarsi snowy white, the former with a narrow subbasal and a broad postmedial brownish black ring, the latter subequal to or a trifle longer than the whitened apex beyond; wings with a faint brown tinge, the oval stigma dark brown; vein 2d A with the arched portion short; abdominal segments dark brown, ringed caudally with yellow.

Female.—Length, about 6.5 millimeters; wing, 7.4.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, with conspicuous glabrous apical necks that are from one-third to one-fourth the length of the enlargement; ventral verticils elongate, the longest fully twice the segment; terminal segment elongate. Head brown; anterior vertex broad.

Pronotum obscure brownish yellow. Mesonotal præscutum uniformly chestnut-brown, the posterior sclerites of mesonotum darker brown. Pleura chiefly obscure yellow on dorsal portion, the ventral pleurites, including the extensive sternopleurite, dark brown. Halteres dark brown. Legs with the coxæ and trochanters dark brown, the posterior coxæ a little paler basally; femora brown, the apices slightly darker; tibiæ snowy white, with a narrow brownish black ring on basal fifth, together with a much wider (approximately four times) brownish black ring on distal half, this subequal to the white annuli on either side; tarsi white; claws simple, hairy on outer faces (a single leg—posterior—remains). Wings (Plate 1, fig. 12, with a faint brown tinge, the oval stigma dark brown; veins dark brown. Venation: Sc_1 ending about opposite the fork of Rs, Sc_2 some distance before the origin of Rs; Rs shorter than the basal section of R_{4+5} and more nearly straight; m-cu close to fork of M; vein 2d A with the arched portion short.

Abdominal tergites dark brown, the caudal margins of the intermediate segments narrowly ringed with pale, the outer segments more uniformly darkened; sternites with the pale apices more extensive. Ovipositor with the tergal valves nearly straight; hypovalvæ very short.

MINDANAO, Davao district, Mount Apo, Mainit River, altitude 6,000 feet, November 5, 1930 (*Clagg*); holotype, female.

Limonia (*Pseudoglochina*) *bilatior* is quite distinct from all regional species of the subgenus, with the exception of the species next described as *L.* (*P.*) *bilatissima* sp. nov. Both species have the second black ring of the tibiæ very broad and conspicuous, but it is less so in the present fly.

LIMONIA (PSEUDOGLOCHINA) BILATISSIMA sp. nov. Plate 1, fig. 13; Plate 3, fig. 36.

General coloration of mesonotum light brown, the præscutum with a narrow darker median line; pleura yellow, the ventral sclerites darker; tibiæ snowy white, with two black rings, the outer broad, subequal to or exceeding twice the white apex beyond; Sc_1 ending opposite origin or to just beyond midlength of Rs; arched portion of vein 2d A short; abdominal tergites dark brown; male hypopygium with the rostral spines very unequal in size.

Male.—Length, about 5.5 millimeters; wing, 6.5.

Female.—Length, about 5 millimeters; wing, 5.8.

Rostrum yellow; palpi black. Antennæ black throughout; flagellar segments (male) with long apical pedicels; verticils a little exceeding the segments in length; terminal segment elongate, about one-third longer than the penultimate; in female, the verticils are longer and more conspicuous, being approximately twice the segments. Head light brown, the front and anterior vertex more yellowish; a darker brown spot on either side of posterior vertex, adjoining the eyes.

Mesonotum light brown, the præscutum with a slightly darker median line, especially evident in front. Pleura yellow, the ventral sternopleurite dark brown. Halteres brownish yellow, the base of stem clearer yellow, the knobs brownish black. Legs with the fore and middle coxæ brown, the posterior coxæ light yellow; trochanters yellow; femora light brown, at tips passing to darker brown; tibiæ snowy white, with two conspicuous black rings, the outer very broad, exceeding twice the white apex; basal black ring of tibia subequal to or only a little narrower than the white ring immediately beyond it; tarsi white. Wings (Plate 1, fig. 13) grayish subhyaline, the oval stigma pale brown; veins dark brown. Costal fringe relatively long and conspicuous in both sexes. Venation: Sc variable in length, Sc_1 ending opposite the origin to shortly beyond midlength of Rs, the latter short and nearly straight; basal section of R_{4+5} gently arcuated; vein 2d A slightly more arcuated than in *bilatior.*

Abdominal tergites dark brown; sternites dimidiate, their bases brown, the apices broadly yellow. Male hypopygium (Plate 3, fig. 36) with the tergite, *9t,* transverse, the caudal margin very gently emarginate. Dorsal dististyle, *dd,* a strongly curved rod, the apex suddenly narrowed into a straight spine. Ventral dististyle, *vd,* fleshy, the rostral prolongation short, with two very unequal spines, the outer stout, from a very broad, slightly elevated base, the inner spine very slender. Gonapophyses, *g,* pale in color.

LUZON, Tayabas Province, Lucban (*Rivera*); holotype, male, January 24, 1931; allotype, female, January 23, 1931; paratypes, 4 males and females, January 24 to 26, 1931.

Limonia (*Pseudoglochina*) *bilatissima* is most nearly allied to *L.* (*P.*) *bilatior* sp. nov. (Mindanao), differing especially in the details of coloration. The outer black ring of the tibia is here unusually broad, subequal to twice the length of the white apex beyond.

ORIMARGA (ORIMARGA) QUADRILOBATA sp. nov. Plate 1, fig. 14; Plate 3, fig. 37.

General coloration black, sparsely pruinose; antennæ and legs black throughout; wings subhyaline, veins brownish black; Rs strongly angulated at origin; cells beyond cord deep; male hypopygium with the tergal region produced into two conspicuous lobes; basistyle on mesal face at cephalic end bearing a strong lobe that is provided with a dense brush of long setæ; inner dististyle bearing a triangular lobe on outer margin at near two-thirds the length.

Male.—Length, about 5 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, becoming progressively smaller to the end; verticils approximately equal in length to the segments. Head gray.

Mesonotum blackish, gray pruinose, the median area of the præscutum broadly of the ground color; centers of scutal lobes similarly blackened. Pleura black, pruinose. Halteres brownish black, the extreme base of stem vaguely brightened. Legs black throughout, the coxæ slightly pruinose. Wings (Plate 1, fig. 14) subhyaline, the veins very distinct, brownish black. Costal fringe of moderate length. Venation: Sc_1 ending just before fork of Rs, Sc_2 at its extreme tip; Rs very strongly angulated at origin; R_{2+3} subequal to the basal section of R_{4+5} and only a little shorter than Rs; cells beyond cord deep; m-cu opposite the point of angulation of Rs; cell 2d A relatively wide.

Abdomen black throughout. Male hypopygium (Plate 3, fig. 37) of very remarkable construction for a member of this usually conservative genus. Region of the tergite, 9*t*, on either side produced into a conspicuous lateral lobe that is provided at apex with several powerful setæ; a group of five or six on margin just before apex being longer and more powerful than are the terminal setæ. Basistyle, *b*, with a powerful lobe on mesal face at cephalic end, this lobe bearing a dense brush of long, sinuous setæ that are more or less decussate across the median line with the set of the opposite style. Outer dististyle of normal conformation, a long, slender, gently curved rod that narrows to the acute tip. Inner dististyle, *id*, longer and wider, flattened, on outer margin at near two-thirds the length with a triangular lobe; apex of style beyond this point densely set with retrorse spinous setæ.

MINDANAO, Davao district, Mount Apo, Galog River, altitude 6,000 feet, October 18, 1930 (*Clagg*); holotype, male.

Orimarga (*Orimarga*) *quadrilobata* is entirely distinct from the other described Philippine species of the genus in the venation, especially the elongate R_{2+3}. In the latter regard, it comes closer to a group of species in China, Japan, and Formosa, such being *O.* (*O.*) *formosicola* Alexander, *O.* (*O.*) *fuscivenosa* Alexander, *O.* (*O.*) *omeina* Alexander, *O.* (*O.*) *pruinosa* Alexander, and others, differing most evidently in the very strongly angulated Rs and the complicated structure of the male hypopygium. The latter character serves to separate this fly from all others in Asia that are known to me and where the male sex has been described.

HELIUS (HELIUS) ANÆMICUS sp. nov. Plate 1, fig. 15; Plate 3, fig. 38.

General coloration yellow; head gray; posterior sclerites of mesonotum darkened; knobs of halteres clear light yellow; legs yellow, the tips of femora narrowly and vaguely darkened; wings pale yellow, the costal and apical portions more saturated yellow; cell R_2 open at margin; inner end of cell 1st M_2 arcuated, with r-m at or beyond midlength of the cell; m-cu just before the fork of M; abdominal segments yellow, narrowly ringed on caudal margins with brown; segments 8 and 9 uniformly brown.

Male.—Length, about 4 millimeters; wing, 4.2.

Rostrum light brown, about equal to the remainder of head; palpi dark brown. Antennæ short, brown; basal flagellar segments short and crowded, the first two closely approximated or slightly united; outer segments more elongate, with conspicuous verticils. Head light gray.

Mesonotal præscutum and scutal lobes clear yellow; median region of scutum more infuscated; scutellum testaceous, infuscated medially at base; postnotal mediotergite infuscated. Pleura testaceous yellow, clearer yellow on the ventral sternopleurite. Halteres pale, the knobs clear light yellow. Legs with the coxæ and trochanters yellowish testaceous; femora yellow, the tips very narrowly and vaguely darkened; tibiæ and tarsi pale yellow, the outer tarsal segments brown. Wings (Plate 1, fig. 15) pale yellow, the costal and apical regions more saturated yellow; veins yellow. Costal fringe short; macrotrichia of veins caudad of R_1 very small and few in number, there being short series on both branches of Rs and on the distal half of the outer section of M_{1+2}. Venation: Rs short and straight, about twice the basal section of R_{4+5}; anterior branch of Rs extending generally parallel to vein R_{1+3}, the outer end of cell R_2 being about as extensive as r-m; inner end of cell 1st M_2 strongly arcuated, so r-m lies at or beyond midlength of cell 1st M_2; m-cu shortly before the fork of M.

Abdominal tergites yellow, the caudal fourth or fifth of the segments brown; a subterminal brown ring on segments 8 and 9; hypopygium yellow; sternites similar in pattern, but with the brown a little less intense. Male hypopygium (Plate 3, fig. 38) with the outer dististyle, *od*, relatively small, straight, bidentate at apex. Inner dististyle, *id*, a little longer. Lateral arm of tergite, 9*t*, appearing as a conspicuous, pale, compressed blade that is extended into a long, straight, more-sclerotized point.

LUZON, Tayabas Province, Lucban, January 27, 1931 (*Rivera*); holotype, male.

Helius (*Helius*) *anæmicus* is very different from all other regional species of the genus. By my key to the Philippine species of *Helius*[7] the present fly runs to *H.* (*H.*) *argyrosterna* Alexander, which is entirely distinct in the coloration, venation, and structure of the male hypopygium.

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[7] Philip. Journ. Sci. 47 (1932) 184.

HELIUS (EURHAMPHIDIA) SCABIOSUS sp. nov. Plate 1, fig. 16; Plate 3, fig. 39.

Belongs to the *indivisus* group; rostrum relatively long, about equal to the remainder of head; femoral tips broadly snowy white, tibial bases usually brightened, tarsi white; eighth and ninth segments of abdomen brownish black; male hypopygium with the lateral arms of tergite slender, entire; distal portion of outer dististyle with microscopic tubercles.

Male.—Length, about 4.2 to 4.5 millimeters; wing, 5 to 5.3.

Rostrum brown, relatively long, subequal to remainder of head; palpi black. Antennæ black throughout; flagellar segments long-oval, with conspicuous verticils. Head gray.

Mesonotal præscutum dark brown medially, the humeral and lateral regions brighter; posterior sclerites of mesonotum chiefly dark brown. Pleura obscure yellow. Halteres brown, the base of stem restrictedly yellow. Legs with the coxæ and trochanters yellowish testaceous; femora dark brown to black, paler basally, the tips broadly and conspicuously snowy white, the tibial bases less distinctly so whitened; in some cases, including the holotype, the amount of white on bases of tibiæ is much reduced; tibiæ black, the tips conspicuously snowy white, the amount including about the distal fourth or slightly more; tarsi snowy white, with segments 4 and 5, together with the apex of 3, dark brown. Wings (Plate 1, fig. 16) with a faint brownish tinge, the costal region a trifle darker; stigma distinct; veins pale brown. Venation: Sc_1 ending opposite r-m; m variable in length.

Abdominal tergites brown, the sternites obscure yellow; eighth and ninth segments brownish black; hypopygium yellow. Male hypopygium (Plate 3, fig. 39) with the lateral arms of the tergite, 9*t*, slender, entire. Outer dististyle, *od*, on distal third or fourth densely set with microscopic tubercles. Inner dististyle terminating in one seta of unusual length and stoutness.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet (*Clagg*); holotype, male, January 28, 1931; paratypes, 2 males, January 30, 1931.

By my key to the Philippine species of *Helius*,[8] the present species runs to couplet 6 which includes its nearest allies, *H.* (*E.*) *indivisus* Alexander (Mindanao) and *H.* (*E.*) *glabristylatus* Alexander (Mindanao), all three forms having the lateral arms of the ninth tergite of the male hypopygium entire and simple and with the tips of the femora broadly white. The present fly is told from *indivisus* by the lack of setulæ on the outer dististyle and from both of the above species by the numerous microscopic tubercles at apex of this style, giving to the organ a scabious or roughened appearance.

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[8] Loc. cit.

HEXATOMINI

Genus EPIPHRAGMA Osten Sacken

Epiphragma OSTEN SACKEN, Proc. Acad. Nat. Sci. Philadelphia for 1859 (1859) 238.

The numerous Philippine species of *Epiphragma* fall naturally within the limits of two subgenera. Of these, the typical subgenus is known only from two species in Mindanao. Elsewhere in the world, *Epiphragma,* s. s., is numerously represented in the Nearctic, Neotropical, Palæarctic, Oriental, and Australasian Regions.

The subgenus *Polyphragma* Alexander[9] is abundantly represented in the Philippines, with more than a score of species described. Representatives have been found only in Luzon and Mindanao, where they are nearly equal in number of discovered forms. Two species, *caninota* and *fuscinota,* have been found in both of these major islands, but most of the remaining species may well prove to be restricted to the island in question. There will undoubtedly be discovered numerous additional forms in the other larger islands of the Archipelago, and likewise in Luzon and Mindanao, which are still insufficiently known. Members of the subgenus have been reported from Borneo but are unknown from the other Malayan islands.

The physical stature of the species is much smaller than usual for the typical subgenus *Epiphragma,* the only one of the Philippine species that at all approaches the latter in size being the subgenotype, *bakeri.* For convenience, I have arranged the known species in five groups, which may be defined briefly as follows:

1. The *bakeri* group. Size large (wing, male, over 10 millimeters); legs almost uniformly darkened. *Epiphragma (Polyphragma) bakeri.*

2. The *ochrinota* group. Mesonotal præscutum reddish to ocherous, scarcely if at all pruinose, contrasting abruptly with the blackened thoracic pleura. Legs chiefly yellow (except in *fuscofasciata*). *Epiphragma (Polyphragma) flavosternata,*

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[9] Philip. Journ. Sci. 45 (1931) 435.

E. (*P.*) *fulvinota, E.* (*P.*) *fuscofasciata, E.* (*P.*) *incisuralis, E.* (*P.*) *latitergata, E.* (*P.*) *ochrinota, E.* (*P.*) *parviloba, E.* (*P.*) *riverana,* and *E.* (*P.*) *triarmata.*

3. The *crenulata* group. Dorsum of head and mesonotal præscutum light ashy-gray, the margins of the latter, together with the thoracic pleura, light yellow or fulvous. Axillary lobe or squama often conspicuously developed. Legs chiefly yellow. *Epiphragma* (*Polyphragma*) *angusticrenulata, E.* (*P.*) *caninota, E.* (*P.*) *cinereinota, E.* (*P.*) *crenulata,* and *E.* (*P.*) *griseicapilla.* Position in group of *E.* (*P.*) *subcrenulata* is doubtful.

4. The *fuscosternata* group. Mesonotum patterned with dark brown; thoracic pleura black, variegated with small yellow spots. Legs chiefly yellow (except in *nigrotibiata*). *Epiphragma* (*Polyphragma*) *apoensis, E.* (*P.*) *fuscosternata, E.* (*P.*) *hastata,* and *E.* (*P.*) *nigrotibiata.*

5. The *fuscinota* group. A single dull-colored species, without bright pattern of the body or legs, with very extensive wing cloudings, and with the interbasal process of the male hypopygium a simple spatulate process. *Epiphragma* (*Polyphragma*) *fuscinota.*

The following species of *Polyphragma* are still known only from the female sex and the structure of the interbasal process of the hypopygium cannot be described or figured: *Epiphragma* (*Polyphragma*) *cinereinota, E.* (*P.*) *fuscofasciata, E.* (*P.*) *fuscosternata,* and *E.* (*P.*) *subcrenulata.* The first three surely fall within the limits of the three major groups, as above defined, but the true position of *subcrenulata* is still in doubt. Despite its different coloration, it appears to be correctly placed in the *crenulata* group, the other members of which have the head and mesonotum light ashy-gray.

The chief characters available for the separation of these rather similar flies lie in the general coloration of the body, wings, and legs; in the wing venation, pattern, and conformation, especially the degree of development of the squama in certain species; and in the details of the male hypopygium. Of the latter structures, the tergite and the interbasal process furnish the features most readily to be seen. I have redrawn outlines of the interbase of all species of which the male sex is known at the present time (Plate 4). The commonest type of structure of the interbase is that of a flattened blade that usually bears an outer apical hook. This type of appearance is lost in the species having the interbase a simple acute spine (*hastata,* *ochrinota, parviloba*), and in *fuscinota* which has a simple spatulate head. In other species this hook is variously developed, being almost lost in *flavosternata.*

Key to the Philippine species of Epiphragma Osten Sacken. (Based chiefly on male characters.)

1. A single supernumerary crossvein in cell C of wings; no supernumerary crossvein in cell Cu. (Subgenus *Epiphragma* Osten Sacken.)........ 2.
A series of supernumerary crossveins and spurs of veins in cell C of wings; a more or less distinct crossvein in cell Cu. (Subgenus *Polyphragma* Alexander.) .... 3.

2. Wings with m-cu shortly beyond the fork of M, far before midlength of cell 1st M_2. (Mindanao; Java.) .... *signata* de Meijere.
Wings with m-cu far beyond midlength of cell 1st M_2. (Mindanao.) *distivena* sp. nov.

3. Larger (wing, male, over 10 millimeters); tibiæ uniformly dark brown; (dark wing pattern not bordered by light margins, hypopygium with interbase unequally bidentate at apex (Plate 4, fig. 46). (Luzon.) .... *bakeri* Alexander.
Smaller (wing, male, under 10 millimeters); tibiæ yellow, dark only in *fuscinota, fuscofasciata,* and *nigrotibiata* (wing-pattern of *fuscofasciata* broadly and conspicuously crossbanded with brown; of *nigrotibiata,* the dark areas of wing narrowly bordered by light yellow; of *fuscinota,* the dark areas of wing so extensive as to almost suffuse the entire disk).

4. Mesonotal præscutum light reddish to ocherous, contrasting abruptly with the uniformly blackened thoracic pleura. (*ochrinota* group.) 5.
Mesonotum not patterned as above, thoracic pleura not uniformly blackened .... 13.

5. Wings with a broad, continuous brown crossbanded pattern, including an area at cord and a narrower one at level of origin of Rs; legs with all femora chiefly blackened, the extreme tip pale yellow; tibiæ chiefly blackened, the posterior tibiæ with the distal sixth yellow; fore and middle tarsi dark, posterior tarsi yellow. (Mindanao.) *fuscofasciata* Alexander.
Wings not so crossbanded; legs not as above, the tibiæ and tarsi yellow. 6.

6. Male hypopygium with the interbasal process a slender, simple, acute spine (Plate 4, figs. 57, 58)........ 7.
Male hypopygium with the interbasal process not an acute spine.... 8.

7. Dark pattern of wing narrowly bordered by light yellow; male hypopygium with the tergite having lobes long and narrow, separated by a narrow U-shaped notch. (Luzon.)........ *ochrinota* Alexander.
Dark pattern of wing not bordered by pale; male hypopygium with the tergal lobes very small, separated by a shallow V-shaped notch. (Luzon.) .... *parviloba* Alexander.

8. Dark pattern of wing narrowly bordered by light yellow........ 9.
Dark pattern of wing not bordered by pale........ 12.

9. Femora brown, the tips narrowly pale yellow; male hypopygium with the interbasal process very long and slender, at apex expanded into a flattened blade (Plate 4, fig. 49). (Luzon.) *flavosternata* Alexander.

Femora yellow, with a narrow, dark, subterminal ring; male hypopygium with the interbase not as above .... 10.

10. Male hypopygium with the interbasal process having a small curved apical hook but without additional lateral projections or flanges (Plate 4, fig. 55). (Mindanao.) .... *latitergata* Alexander.

Male hypopygium with the interbase having a small to large lateral flange, in addition to the apical hook .... 11.

11. Interbase with a large conspicuous flange; apical notch of the structure widely open (Plate 4, fig. 60). (Mindanao.) *triarmata* Alexander.

Interbase with only a weak lateral flange; apex of structure dilated into a long-oval blade, the apical notch so narrow as to be almost closed (Plate 4, fig. 54). (Luzon.) .... *incisuralis* sp. nov.

12. Wings pale yellow, the dark pattern restricted in amount; male hypopygium with lateral lobes of tergite small and broad, about as wide as the notch between them; interbasal process very slender (Plate 4, fig. 59). (Luzon.) .... *riverana* sp. nov.

Wings with the ground color infuscated, with a conspicuous darker pattern; male hypopygium with lateral lobes of tergite very slender, spiniform, separated by a very broad U-shaped notch; interbase not conspicuously narrowed (Plate 4, fig. 50). (Mindanao.) *fulvinota* Alexander.

13. Mesonotum and dorsum of head clear light gray, contrasting conspicuously with the pale margins of the præscutum and with the pleura (*crenulata* group) .... 14.

Mesonotum and dorsum of head not clear gray .... 18.

14. Wings with axillary lobe only slightly developed, its width narrower than cell 2d A at distal end .... 15.

Wings with axillary lobe conspicuously developed, its width equal to or greater than the width of cell 2d A at distal end .... 17.

15. Dark wing pattern narrowly ringed with pale yellow; male hypopygium with the interbasal process having the outer hook very deep (Plate 4, fig. 52). (Mindanao.) .... *griseicapilla* Alexander.

Dark wing pattern not ringed with paler; male hypopygium with the interbase having the outer hook slender, separated from the inner lobe by a conspicuous notch (Plate 4, fig. 44). (Male of *cinereinota* unknown.) .... 16.

16. Abdomen with a blackened subterminal ring; ground color of wing light yellow, the dark color restricted in amount but contrasting with the ground; axillary lobe slightly developed. (Luzon.) *cinereinota* Alexander.

Abdomen without a blackened subterminal ring; ground color of wing brownish, the dark pattern but little conspicuous against this ground; axillary lobe scarcely developed. (Mindanao.) *angusticrenula* Alexander.

17. Dark wing pattern restricted to narrow seams and small marginal spots at ends of longitudinal veins. (Luzon.)
crenulata Alexander.

Dark wing pattern extensive, with large conspicuous clouds at origin of Rs, along cord, and as marginal areas at ends of longitudinal veins. (Luzon; Mindanao.) .... *caninota* Alexander.

18. Mesonotum and pleura dark brown, variegated with yellow spots; dark areas of wing conspicuously bordered by light yellow. (*fuscosternata* group.) .... 19.

Mesonotum and pleura uniform in color; dark areas of wing not bordered by pale .... 22.

19. Tibiæ black. (Mindanao.) .... *nigrotibiata* Alexander.

Tibiæ uniformly yellow .... 20.

20. Cell 1st M_2 of wings long, the second section of vein M_{1+} exceeding vein M_4; petiole of cell M_1 short, subequal to m. (Luzon.)
fuscosternata group.

Cell 1st M_2 of wings shorter, the second section of vein M_{1+2} not exceeding vein M_4; petiole of cell M_1 long, subequal to or exceeding m .... 21.

21. Male hypopygium with the interbase a simple acute spine (Plate 4, fig. 53). (Mindanao.) .... *hastata* Alexander.

Male hypopygium with the interbase short and broad, at apex narrowed to a small curved point (Plate 4, fig. 45). (Mindanao.)
apoensis Alexander.

22. Legs chiefly brown; wing pattern very extensive, the dark coloration nearly suffusing the disk, restricting the ground to small scattered areas. (*fuscinota* group.) (Luzon; Mindanao.)
fuscinota Alexander.

Legs yellow; wings pale yellow, with a restricted dark pattern. (Luzon.) .... *subcrenulata* Alexander.

The species of *Epiphragma* as they occur in the Philippines, with references to their actual occurrence in the islands, are as follows:

Epiphragma (*Epiphragma*) *distivena* sp. nov.; this report.

Epiphragma (*Epiphragma*) *signata* de Meijere; this report.

Epiphragma (*Polyphragma*) *angusticrenula* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. 46 (1931) 468–469. (Plate 4, fig. 44.)

Epiphragma (*Polyphragma*) *apoensis* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. 46 (1931) 462–463. (Plate 4, fig. 45.)

Epiphragma (*Polyphragma*) *bakeri* Alexander; ALEXANDER, Philippines, I, Philip. Journ. Sci. 21 (1922) 373–374; Philippines, X, Philip. Journ. Sci. 46 (1931) 23. (Plate 4, fig. 46.)

Epiphragma (*Polyphragma*) *caninota* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. 46 (1931) 466–467. (Plate 4, fig. 47.)

Epiphragma (*Polyphragma*) *cinereinota* Alexander; ALEXANDER, Philippines, VIII, Philip. Journ. Sci. **45** (1931) 288–289.

Epiphragma (*Polyphragma*) *crenulata* Alexander; ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 293–294. (Plate 4, fig. 48.)

Epiphragma (*Polyphragma*) *flavosternata* Alexander; ALEXANDER, Philippines, VI, Philip. Journ. Sci. **41** (1930) 304. (Plate 4, fig. 49.)

Epiphragma (*Polyphragma*) *fulvinota* Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. **45** (1931) 436–437. (Plate 4, fig. 50.)

Epiphragma (*Polyphragma*) *fuscinota* Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. **45** (1931) 435–436. (Plate 4, fig. 51.)

Epiphragma (*Polyphragma*) *fuscofasciata* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 459–460.

Epiphragma (*Polyphragma*) *fuscosternata* Alexander; ALEXANDER, Philippines, VI, Philip. Journ. Sci. **41** (1930) 304.

Epiphragma (*Polyphragma*) *griseicapilla* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 467–468. (Plate 4, fig. 52.)

Epiphragma (*Polyphragma*) *hastata* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 464–466. (Plate 4, fig. 53.)

Epiphragma (*Polyphragma*) *incisuralis* sp. nov.; this report. (Plate 4, fig. 54.)

Epiphragma (*Polyphragma*) *latitergata* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 460–462. (Plate 4, fig. 55.)

Epiphragma (*Polyphragma*) *nigrotibiata* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 462–463. (Plate 4, fig. 56.)

Epiphragma (*Polyphragma*) *ochrinota* Alexander; ALEXANDER, Philippines, VI, Philip. Journ. Sci. **41** (1930) 303–304. (Plate 4, fig. 57.)

Epiphragma (*Polyphragma*) *parviloba* Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. **46** (1931) 23–24. (Plate 4, fig. 58.)

Epiphragma (*Polyphragma*) *riverana* sp. nov.; this report. (Plate 4, fig. 59.)

Epiphragma (*Polyphragma*) *subcrenulata* Alexander; ALEXANDER, Philippines, VIII, Philip. Journ. Sci. **45** (1931) 287–288.

Epiphragma (*Polyphragma*) *triarmata* Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. **45** (1931) 437–438. (Plate 4, fig. 60.)

The above references to figs. 45 to 60, inclusive, are comparison figures of the interbasal processes of the various species of *Polyphragma*.

EPIPHRAGMA (EPIPHRAGMA) SIGNATA (de Meijere).

Ephiphragma (sic) *signata* DE MEIJERE, Tijdschr. v. Entomol. 54 (1911) 52, pl. 4, fig. 43.

Described from Java. One male, La Lun Mountains, Calian, Davao district, Mindanao, altitude 5,300 feet, July 3, 1930 (*Clagg*).

EPIPHRAGMA (EPIPHRAGMA) DISTIVENA sp. nov. Plate 1, fig. 17; Plate 3, fig. 40.

General coloration ocherous-yellow, the ground color of the præscutum dark brown; pleura variegated with brownish black areas; femora fulvous brown, becoming slightly darker before the narrow yellow tips; wings whitish subhyaline, with an ocellate and banded brown pattern, the areas ocher-yellow, bordered with darker; cell R_3 relatively short, m-cu lying far distad; male hypopygium with the interbase a slender sclerotized rod, the apical third flexible and bent at an angle to the remainder of the rod.

Male.—Length, about 14 millimeters; wing, 13.8.

Rostrum ocher-yellow; basal three segments of maxillary palpi pale yellow, terminal segment uniformly darkened. Antennæ with the scape dark brown; pedicel reddish brown; basal segment of flagellum yellow, the remainder black; flagellar segments cylindrical, with long verticils that slightly exceed the segments; if bent backwards, the antennæ extend to near middistance between the bases of the wings and halteres. Head buffy.

Pronotum yellow, the anterior notum narrowly trivittate with dark brown. Mesonotal præscutum with the ground color dark brown, the four usual stripes extensive, the laterals confluent with the intermediate pair near their anterior ends, isolating the posterior interspaces; intermediate stripes confluent, except for a capillary black vitta on anterior third of sclerite; scutum fulvous-brown, the lobes more or less darkened; scutellum black medially, the margin obscure yellow; postnotal mediotergite with a yellow pollen, variegated with brown on both caudal and cephalic ends. Pleura yellowish white, variegated with small brownish black areas on propleura, two or three on anepisternum, ventral sternopleurite, ventral pteropleurite, and dorsal pleurotergite. Halteres yellow, the distal portion of stem and base of knob a little darkened. Legs with the coxæ light yellow, the fore coxæ with a narrow brown girdle at near midlength, the middle and posterior coxæ narrowly darkened at both base and apex; trochanters yellow; femora fulvous-brown, becoming somewhat darker just before the narrow yellow tips; tibiæ and tarsi yellow, the terminal segments of the latter broken. Wings (Plate 1, fig. 17) whitish subhyaline, with an ocellate and banded pattern that is almost exactly as in *klossi;* areas rich ocher-yellow, bordered with darker; veins yellow, darker in the clouded areas. Venation: Supernumerary cross-vein in cell C long and very oblique; anterior branch of Rs $(R_{2+3}+R_3)$ shorter than cell 1st M_2; m-cu lying far distad, at near three-fifths the length of the cell.

Abdominal tergites with the basal ring fulvous, variegated laterally with dark brown triangles; posterior ring dark brown, conspicuously bordered laterally and caudally with whitish; sternites more uniformly yellow. Male hypopygium (Plate 3, fig. 40) with the interbase, *i,* a slender, sclerotized rod, the distal third flexible, bent at an angle to the axis of the rod.

MINDANAO, Davao district, Mount Apo, Seliban River, altitude 7,000 feet, September 11, 1930 (*Clagg*); holotype, male.

In its general appearance, wing pattern, and venation, *Epiphragma (Epiphragma) distivena* is most nearly allied to *E.* (*E.*) *klossi* Brunetti (Federated Malay States), differing most evidently in the pale femora, these being entirely black in *klossi.* The structure of the interbases is very different from that of all species found in Japan and Formosa.

EPIPHRAGMA (POLYPHRAGMA) FUSCOFASCIATA Alexander.

Epiphragma (*Polyphragma*) *fuscofasciata* ALEXANDER, Philip. Journ. Sci. 46 (1931) 459–460.

Additional specimens show the leg pattern much more distinctly than did the original type material. This arrangement of color on the various legs is quite different from that found in the other species of *Polyphragma.* All femora chiefly blackened, the extreme tips pale yellow; fore and middle tibiæ black, the base narrowly yellow; hind tibiæ similar, the distal sixth paling to yellow; fore and middle tarsi black, the posterior tarsi yellow.

One female, Galog River, Mount Apo, Mindanao, altitude 6,000 feet, October 22, 1930; 1 female, La Lun Mountains, Calian, Davao district, Mindanao, altitude 5,500 feet, January 2, 1931 (*Clagg*).

EPIPHRAGMA (POLYPHRAGMA) INCISURALIS sp. nov. Plate 1, fig. 18; Plate 3, fig. 41; Plate 4, fig. 54.

Belongs to the *ochrinota* group; mesonotum pale brownish ocherous, sparsely pruinose; pleura and sternum dark brown; femora yellow, with a broad brown subterminal ring; wings with the dark brown pattern narrowly ringed with clear yellow; inner end of cell R_4 lying basad of that of cell R_5; male hypopygium with the inner dististyle angularly bent beyond midlength; interbase expanded into an oval blade at apex, terminating in a small hook, the blade subtended by a low flange.

Male.—Length, about 6.5 millimeters; wing, 7.3.

Rostrum dark brown; basal segment of palpus pale brown, the outer segments brownish black. Antennæ with the scape, pedicel, and basal three flagellar segments yellow, the remainder dark brown. Head with the central portion of vertex extensively dark brown, the lateral portions and orbits more reddish, the surface sparsely pruinose.

Mesonotum pale brownish ocherous, the lateral portions of of præscutum more chestnut-brown; surface of notum sparsely pruinose. Pleura and sternum uniformly dark brown, contrasting abruptly with the pale yellow coxæ. Halteres pale yellow, the knobs dark brown. Legs with the coxæ pale yellow, their bases conspicuously dark brown, more broadly so on posterior coxæ; trochanters yellow; femora yellow, with a broad brown subterminal ring; tibiæ and tarsi yellow. Wings (Plate 1, fig. 18) with the ground color pale brown, the prearcular and costal regions clear yellow; a heavy and conspicuous brown pattern that is narrowly bordered by clear yellow; major dark areas at arculus, origin of Rs, along cord, outer end of cell 1st M_2, and as a marginal series at ends of all longitudinal veins, deeper and more intensely brown in the costal and apical portions, becoming more diffuse in the cubital and anal fields; costal crossveins and spurs about six in number; veins dark brown, paler in the clear areas. No axillary crenulation. Venation: Rs relatively long; R_{2+3+4} about twice the basal section of R_5; inner end of cell R_4 lying basad of that of cell R_5; m-cu between one-third and one-half its length beyond the fork of M; supernumerary crossvein in cell Cu distinct.

Abdominal tergites dark brown; hypopygium dark. Male hypopygium (Plate 3, fig. 41) with the tergal lobes, *9t*, broad, separated by a median notch that is a little narrower at apex than either lobe. Outer dististyle, *od*, slender, the apex weakly and unequally bidentate. Inner dististyle longer, at about two-thirds the length bent at a strong angle into a flattened blade. Interbase (Plate 4, fig. 54, *i*) with the proximal portion large and powerful, at apex expanded into a flattened blade, the apical hook of which is separated from the main body of the blade by a small oval to subcircular incision that is closed; on outer face of rod, extending to base of the oval expansion is a low flange.

LUZON, Tayabas Province, Lucban, January 23, 1931 (*Rivera*) ; holotype, male.

The nearest described ally of the present fly is *Epiphragma* (*Polyphragma*) *triarmata* Alexander (Mindanao), which has a somewhat similar wing pattern and condition of the ninth tergite and dististyles of the male hypopygium, but an entirely different interbasal process.

EPIPHRAGMA (POLYPHRAGMA) RIVERANA sp. nov. Plate 1, fig. 19; Plate 3, fig. 42; Plate 4, fig. 59.

Belongs to the *ochrinota* group; mesonotum light reddish brown, the pleura and sternum dark brown; legs yellow, the femur with a broad subterminal brown ring; wings with the ground color almost uniformly pale yellow, with relatively small brown spots; male hypopygium with the lobes of the tergite small, triangular in outline, separated by a U-shaped notch; interbase elongate, a little expanded at apex, terminating in a small curved point.

Male.—Length, about 6 millimeters; wing, 7.

Rostrum and palpi dark brown. Antennæ with the scape, pedicel, and basal two flagellar segments yellow to fulvous, the remainder brownish black. Head brownish black medially, the sides of the posterior vertex reddish brown, the surface very sparsely pruinose.

Mesonotum light reddish brown, the scutellum and postnotal mediotergite darker and sparsely pruinose. Pleura and sternum dark brown, contrasting abruptly with the yellow coxæ. Halteres yellow, the knobs dark brown. Legs yellow, the posterior coxæ darkened at bases; femora with a broad brown subterminal ring. Wings (Plate 1, fig. 19) with the ground color almost uniform pale yellow to grayish yellow, variegated with restricted brown spots that do not form bands or extensive areas; darkened spots at arculus, origin of Rs, cord, outer end of cell 1st M_2, fork of M_{1+2}, and marginal clouds at ends of all longitudinal veins, those of the radial field larger and more distinct. Venation: m-cu variable in position, from close to fork of M to nearly its own length beyond this fork.

Abdominal tergites light brown, margined caudally and laterally with dark brown; sternites clearer yellow, the caudal margins narrowly dark brown; hypopygium dark brown. Male hypopygium (Plate 3, fig. 42) with the lobes of the tergite, 9*t*, small, triangular in outline, separated by a U-shaped notch. Interbase (Plate 4, fig. 59, *i*) relatively long and slender, at apex a little expanded and terminating in a small curved point.

LUZON, Tayabas Province, Lucban (*Rivera*); holotype, male, January 23, 1931; paratypes, 3 males, January 24 and 25, 1931.

Epiphragma (*Polyphragma*) *riverana* is named in honor of Mr. Francisco Rivera, whose collections of Tipulidæ in many parts of the Philippines have added very materially to our knowledge of the subject. The present fly is most closely allied to *E.* (*P.*) *parviloba* Alexander (Luzon), differing most conspicuously in the structure of the interbasal process of the male hypopygium, which, in *parviloba,* is a long, acutely pointed spine.

Genus LIMNOPHILA Macquart

Limnophila MACQUART, Suit. à Buffon 1 (1834) 95.

The Philippine species of the genus *Limnophila* belong to three subgenera. The typical subgenus *Limnophila* (*Poecilostola,* syn.) has four species that fall into two groups, based on the structure of the gonapophyses. *Limnophila* (*Limnophila*) *petulans* is allied to species such as *L.* (*L.*) *aino* Alexander (northern Japan), *L.* (*L.*) *dicranophragmoides* Alexander (Riukiu Islands), and *L.* (*L.*) *murudensis* Edwards (Borneo). *Limnophila* (*L.*) *benguetana, L.* (*L.*) *bituminosa,* and *L.* (*L.*) *subguttularis* find their nearest ally in the Bornean *L.* (*L.*) *guttularis* Edwards. Elsewhere, members of the typical subgenus are chiefly Palæarctic in distribution, but there are, in many regions of the world, numerous species of the genus whose strict position in subgenera is still in question.

The single local species of *Elæophila* (*Ephelia,* syn.) finds its near ally in *L.* (*E.*) *granulata* Edwards (Borneo), with the other members of the subgenus widely spread over the Holarctic Region. The three closely allied species of *Dicranophragma* are nearly allied to the Javan *L.* (*D.*) *remota* (de Meijere) in the long costal fringe of the male and the retracted position of the supernumerary crossvein in cell R_3. All three Philippine species of this subgenus have the mesonotum unmarked, or virtually so. Elsewhere, members of this subgenus occur only in the eastern Nearctic, eastern Palæarctic and Oriental Regions.

Key to the Philippine species of Limnophila Macquart. (Based in part on male characters.)

1. Wings without supernumerary crossveins in the cells. (Subgenus *Limnophila* Macquart.) .... 2.
   Wings with a supernumerary crossvein in cell R_3 or in cell M........ 5.
2. Legs yellow, the femora with a faint, ill-defined, subterminal brown ring; wing pattern consisting of an abundance of dots and spots, the major areas being in part ocelliform (origin of Rs and along cord); male hypopygium with the gonapophyses appearing as flattened, paddlelike blades. (Mindanao.)........ *petulans* Alexander.
   Legs brown or black; if yellow (*subguttularis*), the tips of the femora and tibiæ narrowly blackened; wing pattern not ocelliform, chiefly restricted to the vicinity of the veins; male hypopygium with the gonapophyses not appearing as flattened blades, their tips terminating in acute spines .... 3.
3. Legs yellow, the tips of the femora and tibiæ narrowly dark brown; wings with numerous brown dots in the medial field. (Mindanao.) *subguttularis* sp. nov.
   Legs chiefly brown or black, especially the tibiæ; wings without isolated brown dots in the outer medial field........ 4.
4. Wings with the dark pattern restricted, the yellow interspaces being much broader than the darkened areas; male hypopygium with the gonapophyses appearing as long, slender points. (Luzon.) *benguetana* Alexander.
   Wings with the ground color much restricted by a dark pattern, the latter areas being equal or greater in extent than the yellow interspaces; male hypopygium with the gonapophyses appearing as flattened blades with only the relatively short apices narrowed into points. (Mindanao.) .... *bituminosa* Alexander.
5. A supernumerary crossvein in cell M of wings. (Subgenus *Elæophila* Rondani.) (Luzon; Mindanao.) .... *igorota* Alexander.
   A supernumerary crossvein in cell R_3 of wings. (Subgenus *Dicranophragma* Osten Sacken.) .... 6.
6. Wings with the darkened areas in outer radial cells large and nearly confluent; spots in cells M, Cu, 1st A, and 2d A tending to form parallel cross-lines. (Mindanao.) .... *radialis* Alexander.
   Wings without large and nearly confluent areas filling the outer radial cells; spots in cells Cu, 1st A, and 2d A small, spotlike, not forming cross-lines .... 7.
7. Halteres with the knobs infuscated; wing pattern very abundantly spotted and dotted with brown in all interspaces; markings along caudal margin tending to form small but distinct circles. (Luzon.) *pardalota* Alexander.

Halteres light yellow; wing pattern more restricted, with relatively sparse brown dots in the interspaces between the major dark areas; marginal areas solid, not forming circles. (Mindanao.)
retracta Alexander.

A list of the Philippine species of *Limnophila*, with references to occurrence, is as follows:

Limnophila (Limnophila) benguetana Alexander; ALEXANDER, Philippines, VIII, Philip. Journ. Sci. **45** (1931) 289–290.
Limnophila (Limnophila) bituminosa Alexander; ALEXANDER, Philippines, XIII, Philip. Journ. Sci. **47** (1932) 189–190.
Limnophila (Limnophila) petulans Alexander; ALEXANDER, Philippines, XIV, Philip. Journ. Sci. **48** (1932) 38–39.
Limnophila (Limnophila) subguttularis sp. nov.; this report.
Limnophila (Elæophila) igorota Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. **46** (1931) 24–25.
Limnophila (Dicranophragma) pardalota Alexander; ALEXANDER, Philippines, VIII, Philip. Journ. Sci. **45** (1931) 291.
Limnophila (Dicranophragma) radialis Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. **45** (1931) 440–441.
Limnophila (Dicranophragma) retracta Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. **45** (1931) 439–440.

LIMNOPHILA (LIMNOPHILA) SUBGUTTULARIS sp. nov. Plate 1, fig. 20; Plate 3, fig. 43.

General coloration dark brown, with a sparse yellow pollinosity; median region of præscutum elevated into a series of weak tubercles; halteres pale yellow; legs yellow, the tips of femora and tibiæ narrowly blackened, more broadly so on the former; wings light yellow, with a conspicuous brown spotted and dotted pattern, the smaller dots being most abundant throughout the whole length of the medial field; male hypopygium with the apex of each gonapophysis suddenly narrowed into a slender beak.

Male.—Length, about 5.8 millimeters; wing, 6.5.

Female.—Length, about 6 millimeters; wing, 6.3.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval with verticils that are fully twice as long as the segments bearing them. Head yellowish brown, the center of the vertex darker brown.

Mesonotum dark brown, with a sparse yellow pollen, leaving traces of three brown stripes; median line of præscutum elevated into weak tubercles, this identical in both sexes and apparently a normal condition; posterior sclerites of mesonotum dark, sparsely pollinose. Pleura black, sparsely pollinose, with indications of narrow, darker, longitudinal stripes across the anepisternum and ventral sternopleurite. Halteres pale yellow.

Legs with the coxæ and trochanters black, sparsely pollinose; femora and tibiæ yellow, the tips very narrowly darkened, more broadly so on the femora; tarsi yellow, the tips of the individual segments narrowly darkened, the terminal two segments uniformly infuscated; legs conspicuously hairy. Wings (Plate 1, fig. 20) with the ground color light yellow, with a conspicuous brown spotted and dotted pattern, including about five major areas, that at the cord nearly continuous across the wing; numerous small dots distributed over the entire length of the medial field; costal cell with a variable number of small spots, additional to the larger costal areas; veins yellow, darker in the infuscated areas. Costal fringe (male) relatively long and conspicuous. Venation: R_2 very faint; m-cu at near midlength of cell 1st M_2.

Abdomen brownish black, including the hypopygium. Male hypopygium (Plate 3, fig. 43) with the outer dististyle, *od,* simple, narrowed to an acute tip, the surface with numerous short setæ. Gonapophyses, *g,* appearing as gently curved pale blades that narrow suddenly before their tips into a slender beaklike portion, before this narrowed portion, on outer margin, with a small denticle. Ædeagus slender, curved at apex.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet (*Clagg*); holotype, male, January 27, 1931; allotype, female, January 30, 1931.

The closest ally of *Limnophila* (*Limnophila*) *subguttularis* appears to be *L.* (*L.*) *guttularis* Edwards (Borneo), which differs in the less conspicuously spotted wings, the outer medial field being free from darkened areas except those along cord, outer end of cell 1st M_2 and at fork of vein M_{1+2}. The darkened tips of the tibiæ are more extensive than those of the femora in *guttularis,* the reverse condition being true in the present species. The Bornean fly differs further in having the pedicel of the antenna paler than the remainder of the organ and with the abdominal sternites pale.

Genus PILARIA Sintenis

Pilaria SINTENIS, Sitzgsber. Naturf. Gesell. Dorpat **8** (1888) 398.

A few species of the typical subgenus *Pilaria* occur in the Philippines, in addition to about an equal number of the endemic group *Eupilaria.* Elsewhere in the world, *Pilaria* s. s. is widely spread throughout the Holarctic and Oriental Regions, with fewer species in the Neotropical and Ethiopian Regions.

Key to the Philippine species of Pilaria Sintenis. (Based in part on male characters.)

1. Cell M_1 lacking; anterior branch of Rs very short, less than one-half R_4, cell R_3 at wing margin being very wide, exceeding four times that of cell R_2; antennæ short in both sexes. (Subgenus *Eupilaria* Alexander.) .... 2.
   Cell M_1 present; anterior branch of Rs elongate, exceeding two-thirds of R_4, cell R_3 at wing margin of normal width, subequal to cell R_2; antennæ (male) elongate. (Subgenus *Pilaria* Sintenis.) .... 4.
2. Tarsi conspicuously white. (Mindanao.) .... *leucopoda* Alexander.
   Tarsi black .... 3.
3. Male hypopygium with the outer dististyle very slender, much narrower than the inner style, subequal in diameter or more slender than the gonapophyses; tergite with low irregular lobes that are separated by a broad U-shaped notch. (Mindanao.) .... *auranticolor* Alexander.
   Male hypopygium with the outer dististyle broad, exceeding one-half the width of the inner style and much wider than the gonapophyses; tergite with two submedian lobes that are separated by a linear notch. (Luzon.) .... *phœnosoma* Alexander.
4. Posterior tarsi conspicuously whitened. (Luzon; Mindanao.) *alboposticata* Alexander.
   Tarsi uniformly pale brown to dark brown .... 5.
5. Mesonotum polished black, the thoracic pleura abruptly yellow. (Luzon; Mindanao.) .... *carbonipes carbonipes* Alexander.
   Mesonotum and pleura entirely polished black. (Mindanao.) *carbonipes holomelania* Alexander.

The Philippine members of *Pilaria,* with references to their occurrence in the islands, are as follows:

Pilaria (Eupilaria) auranticolor Alexander; ALEXANDER, Philippines, XIV, Philip. Journ. Sci. 48 (1932) 39–40.

Pilaria (Eupilaria) leucopoda Alexander; ALEXANDER, Philippines, XIII, Philip. Journ. Sci. 47 (1932) 190–191.

Pilaria (Eupilaria) phœnosoma Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 25–27.

Pilaria (Pilaria) alboposticata Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 28; this report.

Pilaria (Pilaria) carbonipes carbonipes Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 27–28; this report.

Pilaria (Pilaria) carbonipes holomelania Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 28.

PILARIA (PILARIA) ALBOPOSTICATA Alexander.

Pilaria alboposticata ALEXANDER, Philip. Journ. Sci. 46 (1931) 28.

Described from Luzon. One male, Mainit River, Mount Apo, Davao district, Mindanao, altitude 6,000 feet, September 9, 1930 (*Clagg*).

PILARIA (PILARIA) CARBONIPES CARBONIPES Alexander.

Pilaria carbonipes ALEXANDER, Philip. Journ. Sci. 46 (1931) 27–28.

Described from Luzon. What seem to be exactly the same race are from various stations on Mount Apo, Davao district, Mindanao. Mainit River, altitude 6,000 feet, September 22, 1930; Kidopawan trail from Lake Lino, altitude 7,000 to 8,000 feet, September 30, 1930; Lake Lino, altitude 8,000 feet, September 19, 1930 (*Clagg*).

ERIOPTERINI

TRENTEPOHLIA (MONGOMA) FULVINOTA sp. nov. Plate 1, fig. 21.

General coloration of mesonotum light fulvous-yellow; head dark, the posterior vertex weakly carinate; antennal verticils short; legs brownish black, the tarsi paling to yellow; wings cream-colored, the stigma small but distinct; R_{3+4} short but distinct; inner ends of cells R_5 and M_3 nearly in alignment.

Male.—Length, about 6 millimeters; wing, 7.

Female.—Length, about 6.5 millimeters; wing, 7.

Rostrum brown, the palpi black. Antennæ black throughout; flagellar segments long-oval to subcylindrical, with verticils that are shorter than the segments. Head brownish black, the anterior vertex narrow, the posterior vertex carinate medially.

Cervical sclerites black. Mesonotum light fulvous yellow, in cases with the posterior sclerites slightly more infuscated. Pleura obscure yellow, the dorsopleural region and ventral sternopleurite very weakly darkened. Halteres dark brown, the base of stem restrictedly yellow. Legs with the coxæ brownish yellow; trochanters obscure yellow; femora brownish black, paler at bases; tibiæ and most of basitarsi brownish black, the remainder of tarsi paling to obscure yellow; posterior tibiæ with a single enlarged spinous seta at apex; proximal end of basitarsi with a dense grouping of the ordinary setæ. Wings (Plate 1, fig. 21) with a creamy tinge, the prearcular and costal regions clearer yellow; stigma small but distinct; veins dark brown, some, especially the posterior cord, vaguely seamed with darker. Venation: R_2 from three to four times as long as R_{3+4}; inner ends of cells R_5 and M_3 nearly in transverse alignment; m-cu at or close to fork of M; fusion of veins Cu_1 and 1st A short.

Abdominal tergites dark brown, the caudal portions of the segments narrowly brownish black, the extreme edges pale; basal sternites brownish yellow; hypopygium brownish black. Ovipositor with the genital shields obscure yellow, cerci relatively elongate, horn-brown.

MINDANAO, Davao district, Mount Apo (*Clagg*); holotype, male, altitude 7,000 to 8,000 feet, Kidapawan trail from Lake Lino, September 20, 1930; allotype, female, altitude 6,000 feet, Baroring River, November 10, 1930; paratopotype, male, with the holotype; paratypes, 2 males, with the allotype; 1 male, altitude 6,500 feet, Sibulan River, September 1, 1930; 6 males and females, La Lun Mountains, altitude 5,500 feet, July 2, 1930, December 31, 1930, January 1, 1931.

By my key to the Philippine species of *Trentepohlia*,[10] the present species runs to couplet 8, agreeing most closely with *T.* (*M.*) *riverai* Alexander (Luzon) which differs in the small size, dark brown coloration, and the details of venation, as the less erect R_3, with cell R_2 at margin correspondingly much wider.

TRENTEPOHLIA (MONGOMA) TENEROIDES sp. nov. Plate 1, fig. 22.

General coloration of mesonotum dark brown; rostrum brownish black; antennæ black, the flagellar segments without modified verticils; legs elongate, black, the tips of the femora narrowly, of the tibiæ more broadly whitened; tarsi white; wings with a faint brown tinge, cells C and Sc blackened; inner end of cell M_3 lying proximad of the other cells that lie at outer end of cell 1st M_2.

Male.—Length, about 9 millimeters; wing, 8.5.

Female.—Length, about 8.5 millimeters; wing, 8.

Rostrum and palpi brownish black. Antennæ black throughout; flagellar segments subcylindrical, with short verticils. Head black, sparsely pruinose; anterior vertex narrow; posterior vertex carinate.

Pronotum dark brown. Mesonotal præscutum and centers of scutal lobes dark brown, the median region of scutum obscure yellow; scutellum and postnotum darkened medially, paler on sides. Pleura obscure yellow, infuscated on the anepisternum and dorsal sternopleurite. Halteres blackened. Legs with the fore and middle coxæ infuscated, the posterior coxæ paler; trochanters obscure yellow; femora black, the tips narrowly but conspicuously white; tibiæ dark brown, the tips broadly whitened; tarsi white, the proximal ends of basitarsi a little infumed; legs very long and slender (male, hind leg, femur, 16.3 millimeters; tibia, 17; tarsus, 10); femora (fore legs missing) with a series of long setæ on lower face, these longest at proximal end of segment, becoming progressively smaller outwardly. Wings (Plate 1, fig. 22) with a faint brown tinge; cells C and Sc conspicuously blackened; wing margin in outer radial field vaguely darkened; veins brown. Venation: Rs subequal to or a little longer than basal section of R_5 and somewhat more than one-half R_{2+3+4}; R_{3+4} distinct but variable in length, shorter than R_2; veins R_3 and R_4 not strongly divergent; inner end of cell M_3 lying far proximad of the other cells that lie at outer end of cell 1st M_2; m-cu at or close to fork of M; apical fusion of veins Cu_1 and 1st A slight.

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[10] Philip. Journ. Sci. 43 (1930) 297–298.

Abdominal tergites dark brown; sternites similar, vaguely brightened laterally.

MINDANAO, Davao district, Mount Apo (*Clagg*); holotype, male, altitude 6,500 feet, Mainit River, September 14, 1930; allotype, female, altitude 7,000 feet, Baroring River, November 9, 1930.

By my key to the Philippine species of *Trentepohlia*,[11] the present fly runs to couplet 5, disagreeing with both included forms, *saxatilis* Alexander and *tenera* (Osten Sacken), in the darkened tibiæ. I consider that *tenera* is the closest ally of the present species, which is distinguished by the darkened tibiæ and the darkened costal margin of the wing.

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[11] Loc. cit.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *dd*, dorsal dististyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *t*, 9th tergite; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Tipula* (*Indotipula*) *latilobata* sp. nov., wing.
2. *Tipula* (*Indotipula*) *angustilobata* sp. nov., wing.
3. *Tipula* (*Tipulodina*) *varitarsis* sp. nov., wing.
4. *Tipula* (*Tipulodina*) *deprivata* sp. nov., wing.
5. *Limonia* (*Limonia*) *capella* sp. nov., wing.
6. *Limonia* (*Limonia*) *brachyneura* sp. nov., wing.
7. *Limonia* (*Limonia*) *browni* sp. nov., wing.
8. *Limonia* (*Dicranomyia*) *suborthia* sp. nov., wing.
9. *Limonia* (*Dicranomyia*) *orthioides* sp. nov., wing.
10. *Limonia* (*Rhipidia*) *servilis* sp. nov., wing.
11. *Limonia* (*Euglochina*) *captiosa* sp. nov., wing.
12. *Limonia* (*Pseudoglochina*) *bilatior* sp. nov., wing.
13. *Limonia* (*Pseudoglochina*) *bilatissima* sp. nov., wing.
14. *Orimarga* (*Orimarga*) *quadrilobata* sp. nov., wing.
15. *Helius* (*Helius*) *anæmicus* sp. nov., wing.
16. *Helius* (*Eurhamphidia*) *scabiosus* sp. nov., wing.
17. *Epiphragma* (*Epiphragma*) *distivena* sp. nov., wing.
18. *Epiphragma* (*Polyphragma*) *incisuralis* sp. nov., wing.
19. *Epiphragma* (*Polyphragma*) *riverana* sp. nov., wing.
20. *Limnophila* (*Limnophila*) *subguttularis* sp. nov., wing.
21. *Trentepohlia* (*Mongoma*) *fulvinota* sp. nov., wing.
22. *Trentepohlia* (*Mongoma*) *teneroides* sp. nov., wing.

PLATE 2

FIG. 23. *Tipula* (*Indotipula*) *latilobata* sp. nov., antenna, basal seven segments.
24. *Tipula* (*Indotipula*) *latilobata* sp. nov., male hypopygium, details.
25. *Tipula* (*Indotipula*) *manobo* sp. nov., male hypopygium, details.
26. *Tipula* (*Indotipula*) *ubensis* sp. nov., male hypopygium, details.
27. *Tipula* (*Indotipula*) *ifugao* sp. nov., male hypopygium, details.
28. *Tipula* (*Indotipula*) *angustilobata* sp. nov., antenna, basal seven segments.
29. *Tipula* (*Indotipula*) *angustilobata* sp. nov., male hypopygium, details.
30. *Tipula* (*Tipulodina*) *varitarsis* sp. nov., male hypopygium, styli.
31. *Limonia* (*Limonia*) *capella* sp. nov., male hypopygium.
32. *Limonia* (*Limonia*) *brachyneura* sp. nov., male hypopygium.

PLATE 3

FIG. 33. *Limonia* (*Limonia*) *browni* sp. nov., male hypopygium.
34. *Limonia* (*Dicranomyia*) *suborthia* sp. nov., male hypopygium.
35. *Limonia* (*Rhipidia*) *servilis* sp. nov., male hypopygium.
36. *Limonia* (*Pseudoglochina*) *bilatissima* sp. nov., male hypopygium.
37. *Orimarga* (*Orimarga*) *quadrilobata* sp. nov., male hypopygium.
38. *Helius* (*Helius*) *anæmicus* sp. nov., male hypopygium.
39. *Helius* (*Eurhamphidia*) *scabiosus* sp. nov., male hypopygium.
40. *Epiphragma* (*Epiphragma*) *distivena* sp. nov., male hypopygium.
41. *Epiphragma* (*Polyphragma*) *incisuralis* sp. nov., male hypopygium.
42. *Epiphragma* (*Polyphragma*) *riverana* sp. nov., male hypopygium.
43. *Limnophila* (*Limnophila*) *subguttularis* sp. nov., male hypopygium.

PLATE 4

FIG. 44. *Epiphragma* (*Polyphragma*) *angusticrenula* Alexander, male hypopygium, interbasal process.
45. *Epiphragma* (*Polyphragma*) *apoensis* Alexander, male hypopygium, interbasal process.
46. *Epiphragma* (*Polyphragma*) *bakeri* Alexander, male hypopygium, interbasal process.
47. *Epiphragma* (*Polyphragma*) *caninota* Alexander, male hypopygium, interbasal process.
48. *Epiphragma* (*Polyphragma*) *crenulata* Alexander, male hypopygium, interbasal process.
49. *Epiphragma* (*Polyphragma*) *flavosternata* Alexander, male hypopygium, interbasal process.
50. *Epiphragma* (*Polyphragma*) *fulvinota* Alexander, male hypopygium, interbasal process.
51. *Epiphragma* (*Polyphragma*) *fuscinota* Alexander, male hypopygium, interbasal process.
52. *Epiphragma* (*Polyphragma*) *griseicapilla* Alexander, male hypopygium, interbasal process.
53. *Epiphragma* (*Polyphragma*) *hastata* Alexander, male hypopygium, interbasal process.
54. *Epiphragma* (*Polyphragma*) *incisuralis* sp. nov., male hypopygium, interbasal process.
55. *Epiphragma* (*Polyphragma*) *latitergata* Alexander, male hypopygium, interbasal process.
56. *Epiphragma* (*Polyphragma*) *nigrotibiata* Alexander, male hypopygium, interbasal process.
57. *Epiphragma* (*Polyphragma*) *ochrinota* Alexander, male hypopygium, interbasal process.
58. *Epiphragma* (*Polyphragma*) *parviloba* Alexander, male hypopygium, interbasal process.
59. *Epiphragma* (*Polyphragma*) *riverana* sp. nov., male hypopygium, interbasal process.
60. *Epiphragma* (*Polyphragma*) *triarmata* Alexander, male hypopygium, interbasal process.

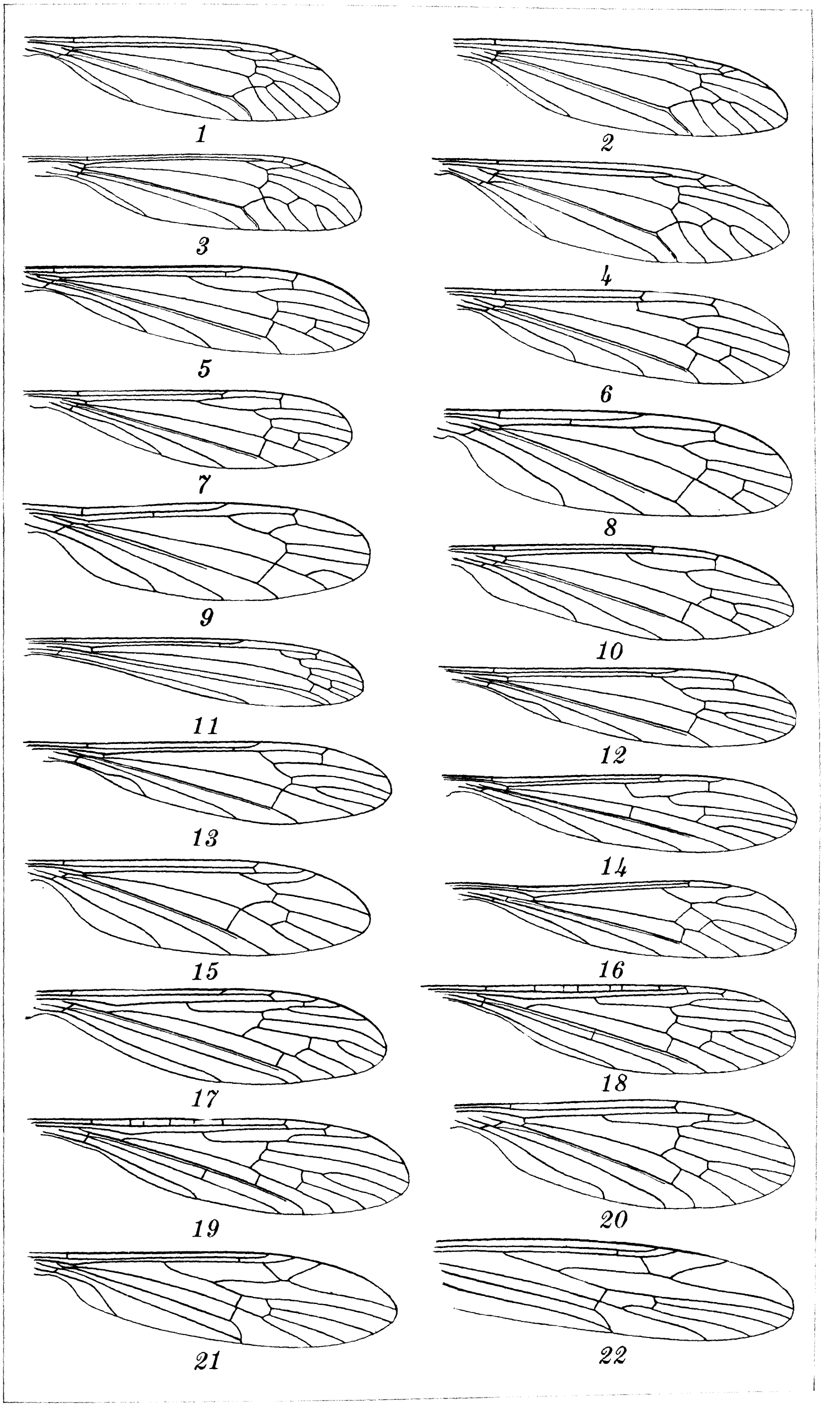
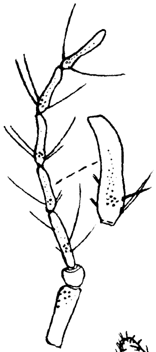


PLATE 1.



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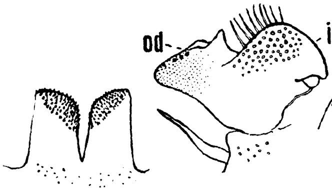

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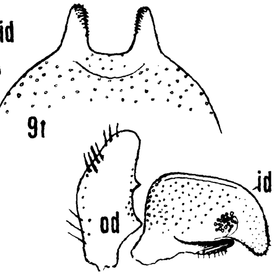

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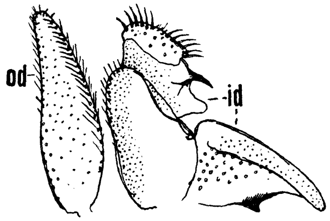

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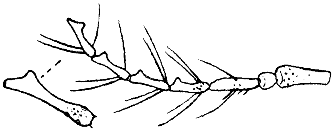

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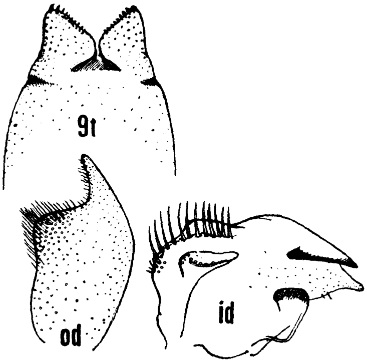

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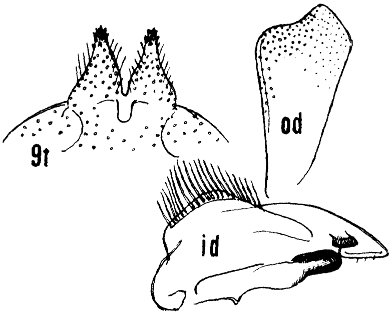

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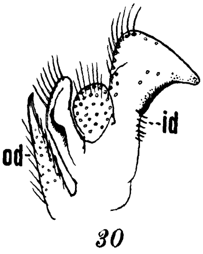

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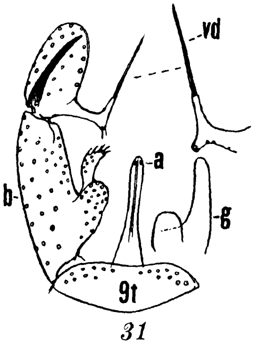

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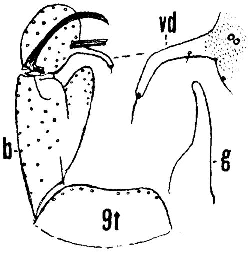

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PLATE 2.

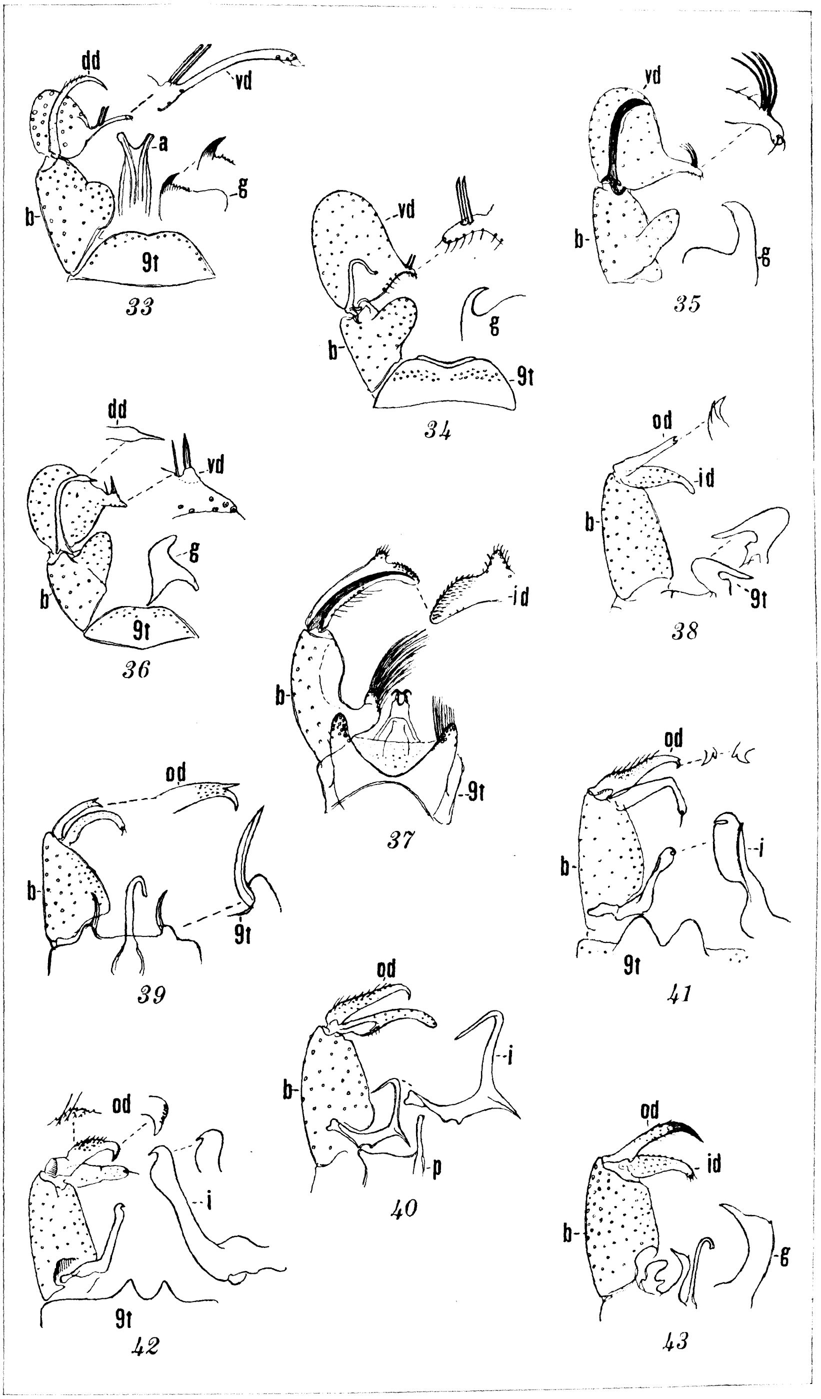
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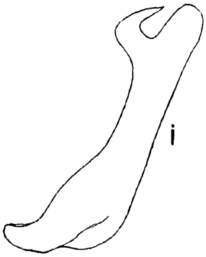
PLATE 3.



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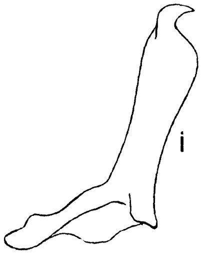

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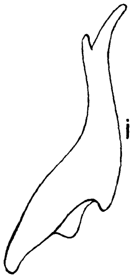

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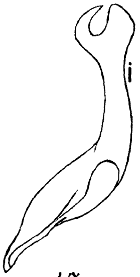

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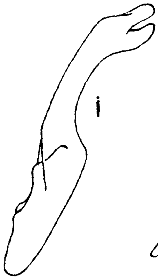

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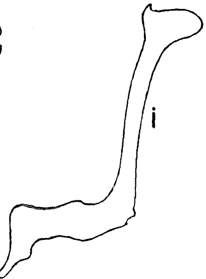

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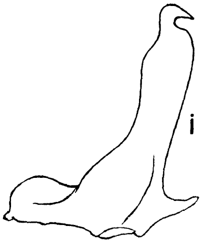

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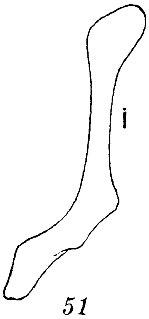

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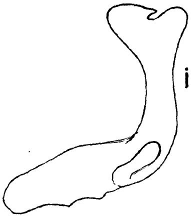

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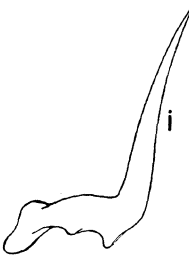

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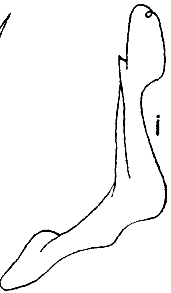

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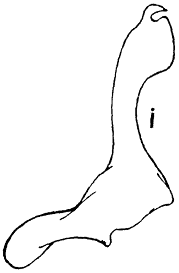

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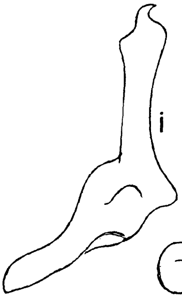

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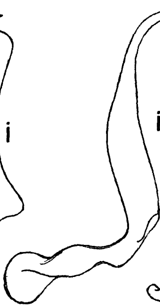

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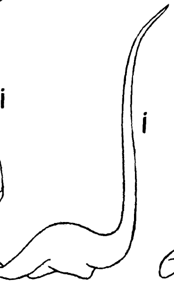

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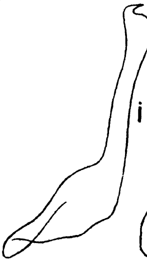

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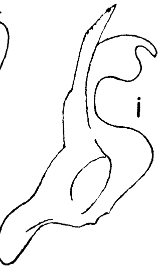

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PLATE 4.

UNIV. OF MICH.

BAKER'S ENTOMOLOGICA MALAYANA: THE ICHNEUMONID GENUS DIAPETUS CAMERON

By R. A. CUSHMAN

Of the Bureau of Entomology, United States Department of Agriculture Washington

TWO TEXT FIGURES

This paper is based very largely on material in the C. F. Baker collection. In this material are included species referable to *Diapetus* Cameron, *Earrana* Cameron, *Parca* Morley, *Microchorus* Szepligeti, and *Esuchonematopodius* Cushman. I have, in fact, been able to identify the genotypes of all except *Earrana* and *Parca*, which I believe to be conspecific. The material available consists of upward of three hundred specimens representing fourteen species.

A study of these specimens leads to the conclusion that *Earrana, Parca*, and *Esuchonematopodius* cannot be held distinct from *Diapetus*, and that *Microchorus* is so much more closely related to *Diapetus* than either is to any other genus that it should logically be treated as no more than a subgenus of *Diapetus*. This is the status accorded it in this paper.

Genus DIAPETUS Cameron

Head polished, broader than thorax, convexly narrowed behind eyes; eyes large and prominent; occipital carina developed only below; ocelli small; clypeus large, broad, strongly convex, broadly arcuate or subtruncate at apex; mandibles long and narrow, the lower tooth very small and sometimes obsolete; palpi slender; antennæ very slender filiform, nearly or quite as long as body, with more than forty joints, scape nearly hemispherical, obliquely truncate.

Thorax polished, rarely coarsely punctate, slender; epomia strong, sometimes forming a tooth above on each side of pronotum; notauli deep, confluent posteriorly, prescutum and lateral lobes strongly convex; scutellum convex, not margined to apex; sternauli deep anteriorly, distinct or obsolete posteriorly; prepectus with a distinct carina or tubercle opposed to the lower posterior angle of pronotum, the prepectal carina erased above;

mesosternum with a prominent transverse carina before middle coxæ; propodeum long; basal carina prominent, apical carina complete, incomplete, or absent; spiracles large, elongate oval; legs very slender; wings narrow, stigma very narrow with radius far before middle, areolet very minute, open, first intercubitus obsolete to very short, recurrent subinterstitial, discocubitus and second recurrent nearly straight, nervulus strongly antefurcal, nervellus strongly reclivous and usually broken above middle.

Abdomen very slender; first segment very little broadened toward apex, with a small tooth on each side, at base, spiracles at or a little before middle, sternite extending far beyond spiracles; second tergite long, slightly constricted near base, gastrocœli very small, distant from base and connected with base by short, oblique grooves; tergites beyond first very finely alutaceous and with dense, fine pubescence; ovipositor very slender, sheath at most twice as long as first tergite.

Most of the above characters ally *Diapetus* with *Nematopodius* Gravenhorst, and it is evidently the Oriental Region analogue of that genus. Nothing is known of its habits or biology. The following key to species includes both subgeneric and specific characters.

Key to the species of Diapetus Cameron.

1. Epomia ending above in a prominent tooth on upper margin of pronotum; male genitalia very long and slender. (Subgenus *Microchorus* Szepligeti, fig. 2.) .... 2.
Epomia not toothed above and not reaching upper margin of pronotum; male genitalia of normal form. (Subgenus *Diapetus* Cameron, fig. 1.) .... 5.

2. Head and mesoscutum black with ivory white markings, mesoscutum with a median white spot; female. (Basilan; Mindanao.) *tricolor* sp. nov.
Head and mesoscutum at most piceous and then without a median white spot on mesoscutum .... 3.

3. Flagellum and stemmaticum ferruginous, stigma stramineous; female and male. (Luzon; Sibuyan; Panay.) .... *philippinensis* Cushman.
The above-named parts black or fuscous .... 4.

4. Prescutum much higher than lateral lobes; carina separating first tergite from sternite distinct throughout; male genitalia nearly as long as first tergite, the apical portion much longer than basal portion; female and male. (Java; Singapore; Penang; Borneo; Formosa.) *mirabilis* (Szepligeti).
Prescutum not much higher than lateral lobes of mesoscutum; carina separating first tergite from its sternite obsolete or wanting; male

genitalia much shorter than first tergite, the slender apical portion not much longer than the stout basal portion; female and male. (Basilan; Mindanao; Samar.) .... *uniformis* sp. nov.

5. Lateral lobes of mesoscutum without longitudinal grooves.................. 6.
   Lateral lobes of mesoscutum each with a longitudinal groove .... 15.
6. Head and thorax black and pale yellow .... 7.
   Head and thorax testaceous or ferruginous, rarely more or less piceous, but without a definite contrasting pattern .... 8.
7. Apical carina of propodeum complete; propodeum with a single black band across base; female and male. (Borneo.)
   nigroplagiatus Cameron.
   Apical carina developed only laterally; propodeum with two transverse black bands; female. (Sikkim.)............... *nigromaculatus* (Cameron).
8. Wings apically infumate; female. (New Guinea.)
   dimidiatus (Brullé).
   Wings entirely hyaline .... 9.
9. Flagellum pale ferruginous or yellow; female and male. (Luzon.)
   pallidicornis sp. nov.
   Flagellum largely fuscous or reddish fuscous .... 10.
10. Propodeum entirely without trace of apical carina; frontal scrobes not separated by a carina .... 11.
    Propodeum with at least distinct lateral traces of apical carina (sometimes complete); frontal scrobes separated by a short, weak, median carina .... 12.
11. Mesosternum with a distinct rounded tubercle at each end of the normally strong transverse carina; postnervulus broken distinctly below middle; female and male. (Mindanao; Basilan.).... *unicolor* sp. nov.
    Mesosternum without tubercles, the transverse carina unusually weak; postnervulus broken distinctly above middle; female and male. (Luzon; Mindanao.) .... *parvus* sp. nov.
12. More or less piceous; female and male. (Borneo.).... *piceatus* sp. nov.
    Entirely ferruginous or stramineous .... 13.
13. Hind tibiæ and tarsi fuscous; stigma and costa black; female. (Ceylon.) .... *luteus* (Cameron).
    Hind tibiæ and tarsi ferruginous; stigma and costa at most subinfuscate .... 14.
14. Front coxa with a high oblique ridge in front; female and male. (Formosa.) .... *taiwanensis* sp. nov.
    Front coxa normal; female and male. (Penang; Java; Hainan; Basilan; Mindanao.) .... *dissipus* sp. nov.
15. Thorax smooth, with evident but not coarse punctures; flagellum with a reddish annulus beyond middle; female and male. (Mindanao.)
    fossulatus sp. nov.
    Thorax rough with very coarse punctures; flagellum not annulated.. 16.
16. Flagellum and hind tarsi reddish or yellowish; female and male. (Luzon.) .... *luzonensis* (Cushman).
    Flagellum and hind tarsi blackish; female and male. (Mindanao.)
    mindanao sp. nov.

Subgenus DIAPETUS Cameron

Diapetus CAMERON, Journ. Straits Branch Roy. Asiatic Soc. 37 (1902) 53. Genotype, *Diapetus nigroplagiatus* Cameron.

Earrana CAMERON, Spolia Zeyl. 3 pt. 10 (1905) 119, pl. 3, fig. 3. Genotype, *Earrana lutea* Cameron (new synonymy).

Parca MORLEY, Rev. Ichn. Brit. Mus. pt. 2 (1913) 133; Faun. Brit. Ind., Hym. 3 pt. 1 (1913) 361, fig. 102. Genotype, *Parca ocularia* Morley (new synonymy).

Esuchonematopodius CUSHMAN, Philip. Journ. Sci. 20 (1922) 567, fig. 7. Genotype, *Esuchonematopodius luzonensis* Cushman (new synonymy).

In the light of the large amount of additional material mentioned above, the characters originally assigned to *Esuchonematopodius* shrink, in my opinion, to at most specific significance. In evaluating these characters it must be remembered that the genus was originally compared not with *Earrana* in the strict sense but with a species erroneously assigned to *Earrana* and properly referable to the subgenus *Microchorus*.

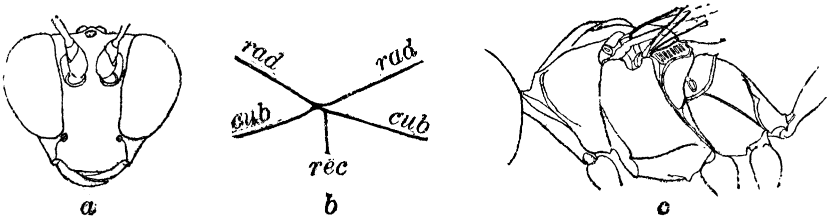

FIG. 1. *Diapetus* (*Diapetus*) *luzonensis* (Cushman); *a*, head, front view; *b*, venation in areolar region; *rad*, radius; *cub*, cubitus; *rec*, recurrent; *c*, thorax, lateral view.

DIAPETUS (DIAPETUS) NIGROPLAGIATUS Cameron.

Diapetus nigroplagiatus CAMERON, Journ. Straits Branch Roy. Asiatic Soc. No. 37 (1902) 54, female.

Three females and four specimens of the hitherto undescribed male are before me. These are all from the Baker collection and all collected at Sandakan, Borneo. One apparently conspecific male with pale abdomen was taken by E. Jacobson at Subigo, Sumatra, in August, 1913. The females agree almost perfectly with the original description, except in some details of color. Apparently Cameron's specimen had the yellow color rather unusually extensive, notably the yellow of the basal middle of the propodeum and the yellow median streak on first tergite. The medially red frons is also unusual, but occurs in one of the Sandakan specimens. The "short stout keels" of the metapleurum are merely rugæ that vary in number and may or may not be present. A characteristic feature overlooked by Cameron is a small tubercle on the anterior face of the front coxa.

The male is essentially like the female.

DIAPETUS (DIAPETUS) NIGROMACULATUS (Cameron). New combination.

Earrana nigromaculata CAMERON, Tijds. Ent. 50 (1907) 93, female.

This species is unknown to me, but it appears to be distinct from all other species in the two transverse black bands on propodeum and from *nigroplagiatus* in its incomplete apical propodeal carina. It is from Sikkim.

DIAPETUS (DIAPETUS) DIMIDIATUS (Brullé). New combination.

Ischnoceros ? dimidiatus BRULLÉ, Hist. Nat. Ins. Hym. 4 (1843) 262, pl. 42, fig. 1.

Earrana dimidiatus CUSHMAN, Philip. Journ. Sci. 20 (1922) 565.

This species is unknown to me and is placed in the key entirely on the basis of the original description. It appears to be distinct from all of the other species in its apically infumate wings. It was described from New Guinea.

DIAPETUS (DIAPETUS) PALLIDICORNIS sp. nov.

Distinct from all but *luzonensis* (Cushman) in its very pale antennæ and from that species by the lack of grooves on the lateral lobes of the mesoscutum and its smooth, unsculptured integument.

Female.—Length, 12 millimeters; antennæ, 12; ovipositor sheath, 3. Smooth and polished, virtually without sculpture. Occipital carina broadly erased medially; diameter of a posterior ocellus half as long as ocellocular line, anterior ocellus a little larger, postocellar and lateral ocellar lines equal; frons with a shallow median groove, scrobes very poorly defined, not separated by a carina; eyes slightly convergent below; face distinctly broader than long, with a shallow longitudinal impression on each side of middle, scatteringly punctate laterally and below antennæ; clypeus strongly convex, in profile nasutiform, little more than half as long as interfoveal line, scatteringly punctate laterally; malar space three-fourths as long as basal width of mandible; mandibles more than twice as long as broad at base, sparsely punctate; antennæ 45-jointed. Pronotum very sparsely and finely punctate above; prescutum more strongly convex than lateral lobes, notauli and grooves along lateral margins of mesoscutum strongly foveolate; scutellum margined to beyond middle; mesopleurum and sternum sparsely and finely punctate, sternauli deep and crenulate anteriorly, subobsolete posteriorly, transverse sternal carina very high and thin, a subconical tubercle on each side of sternum at ends of carina; metapleurum with minute, scattered punctures; propodeum virtually without trace of apical carina, furrow separating propodeum from metapleurum strongly foveolate; intercubitus distinct; nervellus broken below upper third. Abdomen with very fine, dense, yellowish pubescence; first segment without trace of a suture between tergite and sternite, spiracles at middle, those of second tergite also at middle, second tergite less than three times as long as broad at base.

Pale ferruginous, the face, clypeus, mandibles, antennæ, lower part of thorax, and front coxæ and trochanters more yellowish; legs ferruginous; wings hyaline, veins brown, stigma ferruginous; ovipositor sheath ferruginous.

Male.—Length, 9.5 millimeters; antennæ, 9.5. Eyes straight within and convergent below throughout; face as long as broad; malar space barely half as long as basal width of mandible; antennæ 41-jointed. Abdomen much more slender, second tergite about four times as long as broad at base. Otherwise much as in female.

Type locality.—Mount Maquiling, Luzon, Philippine Islands.

Type.—No. 43929, United States National Museum.

Two specimens from the Baker collection.

DIAPETUS (DIAPETUS) UNICOLOR sp. nov.

Female.—Length, 10.5 millimeters; antennæ, 10.5; ovipositor sheath, 2.6. Very similar structurally to *pallidicornis* Cushman, but distinguishable at once by its nearly black flagellum.

From the above description of *pallidicornis* it differs only as follows: The postocellar line is shorter than the lateral ocellar line; the malar space is two-thirds as long as basal width of mandible; the antennæ are 41-jointed. The punctation of the thorax is even less distinct; the notauli are more finely foveolate and the sternauli almost without foveolæ; the transverse sternal carina is much lower and the flanking tubercles are low and rounded but distinct; the furrow separating propodeum and metapleurum is not foveolate. The flagellum, stigma, and ovipositor sheath are blackish.

Male.—Length, 10 millimeters; antennæ (broken). Differs from the male of *pallidicornis* in the same way as the female differs from the female of that species.

Type locality.—Butuan, Mindanao, Philippine Islands.

Allotype locality.—Basilan, Philippine Islands.

Type.—No. 43930, United States National Museum.

One female and three males, the latter all from Basilan.

DIAPETUS (DIAPETUS) PARVUS sp. nov.

Female.—Length, 6.5 millimeters; antennæ, 6.5; ovipositor sheath, 2. Much smaller and a little more slender than *unicolor* Cushman, and differing from that species otherwise only as follows: The anterior ocellus is not perceptibly larger than the posterior, and the diameter of the latter is less than half as long as ocellocular line, also the postocellar line is shorter as compared with the lateral ocellar line; the antennæ are 34- to 36-jointed. The transverse sternal carina is very low and there is no development of the tubercles at its ends; the propodeal spiracles are broadly oval; the postnervulus is broken distinctly above the middle. The second tergite is three times as long as broad at base. In color it is identical with *unicolor.*

Male.—Essentially like female.

Type locality.—Mount Maquiling, Luzon, Philippine Islands.

Allotype locality.—Los Baños, Luzon.

Type.—No. 43931, United States National Museum.

Six females and five males, the type and four other females and one male from Mount Maquiling, two males from Los Baños, and one female and two males from Iligan, Mindanao.

DIAPETUS (DIAPETUS) LUTEUS (Cameron). New combination.

Earrana lutea CAMERON, Spolia Zeyl. 3 pt. 10 (1905) 120, pl. B, fig. 3, female.

? *Parca ocularia* MORLEY, Rev. Ichn. Brit. Mus. pt. 2 (1913) 133; Fauna Brit. Ind., Hym. 3 Ichn. pt. 1 (1913) 361, fig. 102, female.

I have seen no Ceylonese specimens, nor have I seen any specimen that agrees entirely with either Cameron's or Morley's description; but I have very little doubt that *lutea* and *ocularia* are the same. Certain discrepancies between the descriptions are not borne out by Cameron's figure; as, for example, the ocelli which Cameron says are large as in *Paniscus,* but which are shown small in his figure. The venation in the two figures is identical. Cameron's figure does not accord with his description in that the thorax and hind coxæ as depicted are not three times as long as broad, the front tarsi are not twice as long as the tibiæ, nor are the antennæ longer than the body. Also the propodeum shows no transverse carina.

DIAPETUS (DIAPETUS) TAIWANENSIS sp. nov.

Female.—Length, 11 millimeters; antennæ, 9.5; ovipositor sheath, 2. Smooth and polished with sparse and weak punctures on face, clypeus, pronotum, and meso- and metapleura. Temples strongly receding; anterior and posterior ocelli subequal in size, diameter of a posterior ocellus half as long as ocellocular line, postocellar and lateral ocellar lines equal; frons without a median groove, scrobes subdistinct and separated by a short, weak, median carina; eyes weakly convergent below; face about two-thirds as long as broad; clypeus strongly convex but not nasutiform in profile, a little more than half as long as interfoveal line; malar space very nearly as long as basal width of mandible; mandible more than twice as long as broad; antennæ 36- to 37-jointed (37-jointed in type). Thorax fully two and one-half times as long as broad; epomia reaching only half way to upper margin of pronotum, thence curving forward; prescutum only slightly more strongly convex than lateral lobes, notauli very minutely foveolate; scutellum margined only at base; sternauli sharply defined throughout, minutely foveolate; tubercle of prepectus very prominent; transverse sternal carina low, prominent only at ends, sternum with no tubercles at ends of carina; propodeum with only lateral traces of apical carina; front coxa with a large oblique ridge in front; intercubitus distinct, postnervulus broken at or shortly below or above middle. Abdomen slender, second tergite more than three times as long as broad at base, its spiracles distinctly beyond middle; first segment without trace of suture between tergite and sternite, spiracles at the middle.

Pale ferruginous, face, temples, inner orbits, clypeus, and mandibles yellowish; flagellum reddish fuscous, darker apically; thorax laterally and front and middle coxæ paler; legs otherwise pale ferruginous with hind tarsi darker; wings hyaline, stigma and costa testaceous, veins brown; abdomen slightly darker than thorax; ovipositor sheath blackish.

Male.—Length, 10.5 millimeters; antennæ, 9.5. More slender, but otherwise much like female.

Type locality.—Kankau (Koshun), Formosa.

Type.—Deutsches Entomologisches Museum.

Paratype.—No. 43932, United States National Museum.

Six females and three males, all collected by H. Sauter.

Three female paratypes and one male paratype are in the United States National Museum.

DIAPETUS (DIAPETUS) DISSIPUS sp. nov.

Very similar to *taiwanensis* Cushman but lacks the oblique ridges on the front coxæ characteristic of that species.

Female.—Length, 11 millimeters; antennæ, 11; ovipositor sheath, 2.3. Varies in size from the above to 8 millimeters with sheath 1.7 millimeters. Differs further from the above description of *taiwanensis* as follows: Face three-fourths as long as broad; antennæ 42- to 49-jointed (47 in type). Thorax a little stouter, sternauli obsolete posteriorly; transverse mesosternal carina prominent throughout; apical carina of propodeum complete to broadly interrupted medially; intercubitus very short; nervellus broken distinctly above middle. Spiracles of second tergite at middle. In color like *taiwanensis* except that stigma and costa are infuscate.

Male.—Length, 10.5 millimeters; antennæ, 10.5. Variation in size as in female. More slender, but otherwise much like female.

Type locality.—Iligan, Mindanao, Philippine Islands (Baker collection).

Other localities.—Dapitan, Butuan, Kolambugan, Zamboanga, and Surigao, Mindanao; Basilan (Baker collection); Hainan Island (Nam Cha Chuen, S. W. of Nodoa, July 8, 1929, Lignan University, 5th Hainan Is. Expedition); Buitenzorg, Java, March, 1900 (Bryant and Palmer, collectors); Penang Island (Baker collection).

Type.—No. 43933, United States National Museum.

Described from eighteen females and twenty-one males; twelve females and nineteen males are from Mindanao, two females and two males from Basilan, two females from Penang, and one female each from Hainan and Java.

DIAPETUS (DIAPETUS) PICEATUS sp. nov.

Structurally very similar to *dissipus* Cushman, but with the merest lateral traces of the apical carina of propodeum. Distinct in color, the dorsum of head, thorax, and abdomen being distinctly piceous.

Female.—Length, 7.5 millimeters; antennæ, 6.5; ovipositor sheath, 1.7. Smooth and polished, virtually impunctate; temples strongly convex, but sharply receding; anterior and posterior ocelli subequal in size, postocellar line slightly shorter than lateral ocellar line; frons with a weak median impressed line, scrobes shallowly distinct, separated by a weak carina; eyes weakly convergent below; face very nearly as long as broad;

clypeus in profile very strongly convex, subnasutiform, half as long as interfoveal line; malar space barely half as long as basal width of mandible; mandible more than twice as long as broad; antennæ 35-jointed. Thorax two and a half times as long as broad; epomia reaching little more than half way to upper margin of pronotum; prescutum distinctly more strongly convex than lateral lobes; notauli minutely foveolate; more coarsely so posteriorly; scutellum margined only at base; sternauli sharply defined throughout, minutely foveolate; tubercle of prepectus reduced to a low carina; transverse carina of mesopleurum evenly elevated throughout, no tubercles laterad of carina; apical carina of propodeum virtually wanting; intercubitus short but distinct; postnervulus broken at middle; nervellus slender, second tergite three times as long as broad at base, its spiracles beyond middle; first segment with at most faint traces basally of sutures between tergite and sternite, spiracles at middle.

Ferruginous, head dorsally, mesoscutum, propodeum, and abdomen piceous; face, clypeus, and mandibles stramineous; flagellum blackish; hind femur and tibia somewhat darkened, hind and middle tarsi blackish; wings hyaline, venation blackish, stigma with a testaceous streak in middle; ovipositor sheath blackish.

Male.—Like female except antennæ 37-jointed; abdomen more slender with second tergite fully four times as long as broad at base; piceous color involving upper part of pronotum, mesopleurum, metapleurum, and hind coxæ.

Type locality.—Sandakan, Borneo.

Type.—No. 43934, United States National Museum.

One of each sex from the Baker collection.

DIAPETUS (DIAPETUS) FOSSULATUS sp. nov.

This species stands intermediate between the genotype of *Esuchonematopodius* and the more typical *Diapetus*. The grooves in the lateral lobes of the mesoscutum and the median elevation of the prescutum are weaker than in *luzonensis;* the punctation of head and thorax is much finer, though it is still much coarser than in typical *Diapetus;* the front coxæ lack the oblique ridge; and the frons lacks the transverse carina above the scrobes.

Female.—Length, 11 millimeters; antennæ, 12; ovipositor sheath, 3.5. Temples strongly convex but very narrow; vertex in front view straight across, distinctly below top of eyes; anterior and posterior ocelli subequal, postocellar and lateral ocellar lines subequal; frontal scrobes rather deep and separated by a weak median carina; eyes distinctly convergent below; face three-fourths as long as broad, with a few distinct, but not very large, punctures laterally and above; clypeus strongly convex, with scattered distinct punctures, strongly rounded at apex; malar space two-thirds basal width of mandible; mandible more than twice as long as broad at base. Thorax two and a half times as long as broad, polished, smooth, with sparse, distinct punctures on upper part of pronotum, in middle of mesopleurum, metapleurum, and propodeum; metapleurum and apex of propodeum more or less rugose; epomia reaching about two-thirds across pronotum; prescutum low anteriorly with a subdistinct median longitudinal elevation, lateral lobes with shallow but distinct longitudinal grooves, notauli deep, smooth anteriorly, foveolate posteriorly; scutellum margined at base; sternauli finely foveolate anteriorly, obsolete posteriorly, impression before speculum elongately foveolate; sternum more finely and densely punctate than pleurum, its transverse carina low, not prominent at ends but with a low rounded tubercle opposite each end; apical carina of propodeum developed only laterally; intercubitus very short, postnervulus broken slightly below and nervellus slightly above middle. Abdomen very slender, second tergite fully four times as long as broad at base, its spiracles at middle; first segment very slender, decurved, scarcely wider at apex than at spiracles, which are at middle, suture between tergite and sternite entirely obliterated.

Pale ferruginous, slightly darker above; flagellum ferruginous at base, black at apex, with a paler yellowish ferruginous annulus occupying about joints 13 to 24; wings hyaline, veins brown, stigma and costa ferruginous; legs ferruginous, front and middle coxæ paler, hind tarsi yellowish; ovipositor sheath ferruginous.

Male.—Like female in all essential features.

Type locality.—Butuan, Mindanao.

Type.—No. 43935, United States National Museum.

Seven females and five males all from the Baker collection and all from Mindanao, four females and two males from the type locality, and three of each sex from Iligan. The series shows variation in size from 9 to 12 millimeters and in the strength of the longitudinal prescutal welt and the rugosity of propodeum and metapleurum.

DIAPETUS (DIAPETUS) LUZONENSIS (Cushman). New combination.

Esuchonematopodius luzonensis CUSHMAN, Philip. Journn. Sci. 20 (1922) 567, fig. 7.

Differs from the above description of *fossulatus* principally as follows: Vertex slightly concave, more or less distinctly coarsely punctate as is also the frons laterally, frons medially impressed, scrobes limited above by a transverse carina that is slightly angulated medially at the junction of the median carina; face and clypeus more coarsely punctate, face nearly as long as broad, clypeus less strongly convex; malar space longer; thorax, except pronotum below and scutellum, very coarsely and roughly punctate; grooves of lateral lobes of mesoscutum and median elevation of prescutum stronger; sternal carina higher, tubercles at its ends high and subconical; apical carina of propodeum strongly developed laterally and subangulate, less broadly interrupted; front coxa with a high oblique ridge across anterior face; general color darker and more nearly uniform, face and mouth parts distinctly paler; flagellum pale ferruginous, gradually becoming yellow toward apex; legs more nearly uniform in color.

In addition to the type series nine females and thirteen males are before me. These are all from the Baker collection and mostly from Los Baños and Mount Maquiling, Luzon; two are from northwest Panay and two from the Cuernos Mountains, Negros. This series exhibits variation in size from 8 to 17 millimeters as well as considerable variation in the depth and density of the punctation of head and thorax, the smallest specimen having the pleura nearly smooth.

DIAPETUS (DIAPETUS) MINDANAO sp. nov.

Very similar to *luzonensis* and should perhaps be considered merely a variety of that species, but the flagellum, entire venation, hind tarsi, and ovipositor sheath are black and in specimens of the same size the punctation of head and thorax is less dense and a little smaller in *mindanao* than in *luzonensis*.

Type locality.—Butuan, Mindanao.

Type.—No. 43936, United States National Museum.

Sixteen females and twenty-four males, all but seven from various localities (Butuan, Iligan, Surigao) on Mindanao, the rest from Samar. All are from the Baker collection.

Subgenus MICROCHORUS Szepligeti

Microchorus SZEPLIGETI, Ann. Mus. Nat. Hung. 14 (1916) 288. Genotype, *Microchorus mirabilis* Szepligeti.

Earrana CUSHMAN, Philip. Journ. Sci. 20 (1922) 564, fig. 6 (not Cameron) (new synonymy).

Differs from the typical subgenus only in the prominent teeth at the intersections of the epomia with the dorsal margin of pronotum, in the very long, slender valves of the male genitalia, in the more strongly convergent eyes and shorter malar space, and in the position of the first abdominal spiracle slightly before the middle.

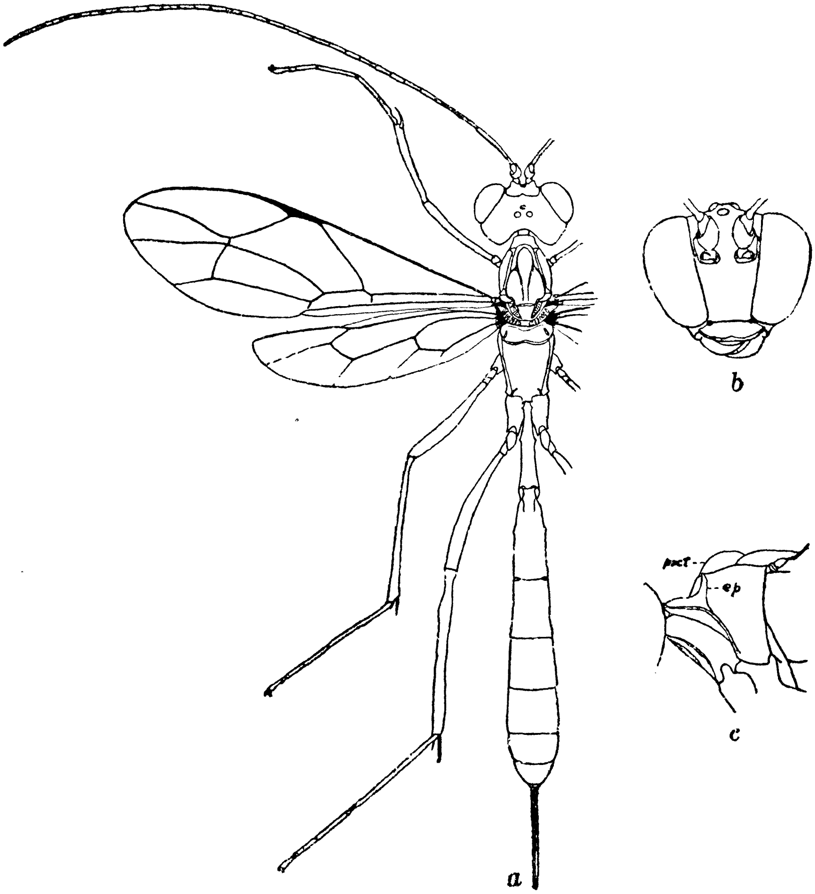

FIG. 2. *Diapetus* (*Microchorus*) *mirabilis* (Szepligeti) ; *a*, dorsal view ; *b*, head, front view ; *c*, thorax, anterior portion, lateral view to show prescutum, *psct*, and epomia, *ep*.

DIAPETUS (MICROCHORUS) TRICOLOR sp. nov.

Distinct from all other species of the subgenus in its contrasting color pattern of ferruginous, black, and ivory.

Female.—Length, 7.5 millimeters; antennæ, 7.5; ovipositor sheath, 1.5. Head and thorax polished; face, upper angle of pronotum, and meso- and metapleura very finely punctate, the face sparsely so; eyes convergent in the ratio 3:2; face fully as long as broad below, with a short groove on each side of middle above clypeus; clypeus more than twice as broad as long, broadly arcuate at apex, moderately convex; malar space less than half as long as basal width of mandible; mandibles fully two and a half times as long as broad at base; antennæ 44-jointed. Thorax nearly three times as long as broad; prescutum more strongly convex than lateral lobes, notauli smooth; scutellum weakly convex, margined only at base; sternauli complete, very finely foveolate; prepectal tubercle in the form of a low carina; apical carina of propodeum represented by merest traces laterally; intercubitus distinct, recurrent nearly interstitial; postnervulus broken below, nervellus distinctly above, middle. Abdomen very slender, second tergite fully four times as long as broad at base and weakly broadening posteriorly; no trace of suture between first tergite and its sternite.

Head black with face, orbits (broadly interrupted behind eyes), clypeus, and mouth parts ivory white; antennæ blackish, scape and pedicel pale ferruginous below, flagellum with a narrow whitish line on outer side of first two or three joints. Thorax ferruginous; mesoscutum, lateral areas of scutellum and postscutellum, and propodeum largely black; collar, upper and anterior margins of pronotum, an elongate central spot on mesoscutum, and tegulæ ivory white; wings hyaline, veins and stigma black; legs ferruginous, front coxæ and trochanters stramineous; hind trochanter piceous above, stramineous below, middle and hind tarsi blackish. First three tergites black to piceous with apices pale; other tergites brownish ferruginous, more or less piceous toward base; sheath black.

Type locality.—Dapitan, Mindanao.

Type.—No. 43937, United States National Museum.

Two females, the paratype from Basilan; both from the Baker collection. The paratype is a little larger, with the black of propodeum somewhat more extensive and the hind coxæ partly piceous on outer side.

DIAPETUS (MICROCHORUS) PHILIPPINENSIS (Cushman). New combination.

A large series of both sexes from the Baker collection are before me. Most of these are from Mount Maquiling and Los Baños, Luzon, one from Malinao, Tayabas, Luzon, three from

Sibuyan, two from northwestern Panay, and two from Cuernos Mountains, Negros.

Structurally very similar to *tricolor,* differing from the above description of that species essentially as follows: Antennæ 50- to 55-jointed; scutellum margined at least to middle; metapleurum usually transversely rugose; apical propodeal carina strong laterally. The sheath of the male genitalia is much shorter than the first tergite.

In color it is very distinct from all other species of the subgenus, being almost uniformly ferruginous with face and clypeus only slightly paler, stemmaticum concolorous, antennæ concolorous basally and yellowish apically, tarsi not at all darkened, and venation testaceous.

DIAPETUS (MICROCHORUS) MIRABILIS (Szepligeti). New combination.

Microchorus mirabilis SZEPLIGETI, Ann. Mus. Nat. Hung. 14 (1916) 288, male.

Earrana malayensis CUSHMAN, Philip. Journ. Sci. 20 (1922) 565, fig. 6, female.

In addition to the types of *malayensis,* there are before me another female and three males from Singapore, a female from Penang Island, and one female and three males from Borneo, all from the Baker collection; one of each sex collected in Sumatra by E. Jacobson; and three females and two males collected by H. Sauter at Kankau, Formosa.

This lot of specimens exhibits great variation in color, and none agrees entirely with Szepligeti's very brief description, in that the face, clypeus, mandibles, and frontal orbits are always yellowish and the stemmaticum is usually black or piceous. In many of the specimens, especially those from Borneo and Sumatra, more or less of the dorsal surface is piceous; this color more or less replacing the ferruginous of the vertex, middle of frons, mesoscutum, propodeum, and abdomen, and even of the hind legs. The Formosan specimens agree best with Szepligeti's description. Structurally the species is very similar to *luzonensis,* but the carina separating the first tergite and its sternite is distinct throughout and the male genitalia are fully as long as the first abdominal segment.

DIAPETUS (MICROCHORUS) UNIFORMIS sp. nov.

Structurally almost identical with *philippinensis,* but differing constantly in its black flagellum, stemmaticum, venation, and ovipositor sheath, and with the apical carina of propodeum less strongly developed. It should, perhaps, be treated merely as a variety of *philippinensis*. From *mirabilis* it differs in the lack of the carina separating first tergite and sternite and in the much shorter male genitalia.

Type locality.—Iligan, Mindanao.

Type.—No. 43938, United States National Museum.

Described from a large series from the Baker collection, consisting of sixteen females and thirty-five males from various localities in Mindanao (Iligan, Kolambugan, Dapitan, Zamboanga, Surigao, Butuan) ; one female and five males from Basilan; and five females and five males from Samar.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Diapetus* (*Diapetus*) *luzonensis* (Cushman); *a,* head, front view; *b,* venation in areolar region; *rad,* radius; *cub,* cubitus; *rec,* recurrent; *c,* thorax, lateral view.

2. *Diapetus* (*Microchorus*) *mirabilis* (Szepligeti); *a,* dorsal view; *b,* head, front view; *c,* thorax, anterior portion, lateral view to show prescutum, *psct,* and epomia, *ep.*

THE MOLLUSCAN INTERMEDIATE HOST IN THE PHILIPPINES OF THE ORIENTAL BLOOD FLUKE SCHISTOSOMA JAPONICUM KATSURADA[1]

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FIVE PLATES

INTRODUCTORY

The occurrence of schistosomiasis japonica or Katayama disease in the Philippines was recorded for the first time in 1906, when Wooley discovered the characteristic ova of *Schistosoma japonicum* in the stools of a Filipino prisoner in Bilibid Prison, Manila. In spite of the fact that the infection seems prevalent in certain places in the Islands, especially in Samar, Leyte, and Mindanao, as judged from the number and distribution of the cases which have since been found, the molluscan intermediate host of the parasite has never been identified locally. In Japan, China, and Formosa, on the other hand, where the disease also occurs, the snail carriers of the causative agent have long been determined.

The determination of the molluscan intermediate host of the Oriental blood fluke in the Philippines is important not only from the purely biological but also from the practical standpoint. In the first place, it may add to the knowledge of the particular kinds of snails capable of harboring the larval stages (parthenitæ) of the parasite. In the second place, it would point definitely to a means of attack against the trematode in case it should be desired to institute measures for its control and prevention. For these reasons it was decided during the early part of the year (1932) to look for the responsible snail in one of the supposedly endemic regions in the southern part of the Archipelago. The town of Palo, Leyte, was chosen as the convenient place for the search. The procedure adopted was first to find cases of the disease and then to examine the mollusks in the bodies of fresh water in the immediate vicinities of the houses of the infested individuals or those frequented by them.

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[1] Read in part before the Philippine Society of Parasitology, April 15, 1932.

ENDEMICITY OF THE DISEASE IN THE AREA SURVEYED

As shown in Table 1, a large number of the schistosomiasis cases that have been encountered in the Philippines came from Leyte. The individuals concerned, however, were transients in the City of Manila, where the diagnoses of their infections were made, and it is not shown in the records in what particular localities they might have contracted the disease. For this reason it was necessary on arriving in Palo to determine if the disease is endemic in that place. If cases could be found, especially among the more permanent members of the population, such as, young children and those adults whose state of life and occupation have not enabled them to travel extensively from one place to another, then the examination of snails might yield the desired information.

TABLE 1.—*Distribution of schistosomiasis cases found in the Philippines.*

Author.	Year.	Mindanao.	Leyte.	Samar.	Luzon.			
					Manila.	La Union.	Rizal.	Bulacan.
Wooley, P. G.	1906	------	------	------	1	------	------	------
Garrison, P. E.	1908	4	5	6	1	------	------	------
Phalen, J. M., and H. J. Nichols	1908	------	------	1	------	------	------	------
Willets, D. G.	1914	------	1	------	1	1	------	------
Guazon, P.	1918	------	------	------	[a] 1	------	------	------
Mendoza-Guazon, M. P.	1912–22	------	1	2	7	------	------	------
Manalang, C.	1925–26	[b] 2	------	------	------	------	------	------
Hizon, J.	1928	1	4	1	4	------	------	------
Ramos, V.	1928	------	1	------	------	------	------	------
De Leon, W.	1931	------	------	------	------	------	[b] 1	------
Africa, C.	1928–32	------	[b] 2	[b] 1	------	------	------	------
Ira Concepcion, J.	1932	------	------	------	------	------	------	[b] 1
Totals	----------	7	14	11	15	1	1	1

[a] According to Mendoza-Guazon (1922). [b] Unpublished.

With the coöperation of two prominent citizens of the town, to whom the symptoms of the disease and its mode of transmission were described, eleven typical cases were located without much difficulty. Four of them were young girls, 10 to 17 years of age, the rest males, 8 to 43 years old. The clinical manifestations of the disease in the later stages were evident in most of them; namely, the distension of the upper half of the abdomen due to the enlargement of the liver and spleen, diarrhœa with blood and mucus, irregular fever, anæmia, cachexia, œdema, and ascites (Plate 2, figs. 1 and 2). The younger members of the series appeared stunted, both sexually and physically. All of them were found to be discharging the ova of *Schistosoma japonicum* in their fæces (Plate 3, fig. 1).

With the exception of one of the girls and the eldest male of the series, none of these persons has been outside of Palo. They all belong to the rice-farming class; and when the history of each one of them was taken, some very elucidating information, which led to the early discovery of the snail carrier of the parasite, was obtained. Some of them remembered having suffered on a number of occasions from severe itching on the legs and arms after working in their rice paddies or catching fish in a certain brook. In the case of two brothers, according to their parents, they were quite healthy during their residence in a barrio where they were born. Their present illness became noticeable about three years ago after they had moved to work on newly acquired rice land in another barrio.

DISCOVERY OF THE MOLLUSCAN INTERMEDIATE HOST

In searching for the local intermediate host of *Schistosoma japonicum,* it was surmised that the responsible snail would prove to be one quite similar in habits and appearance to the known carriers of the fluke in Japan, China, and Formosa; hence no special attention was paid to species such as those of *Melania, Bulinus, Ampullaria, Vivipara,* and other genera of fresh-water mollusks that are commonly met with in the Philippines. Such a snail was naturally looked for, as already mentioned, in bodies of water near the residences of sick individuals, whose stools were positive for schistosome ova, or in those which, according to the histories of some of the patients, were suspected to be possible foci of infection.

January 27, 1932, after a two-day search, a small snail presenting the characters of the genus *Oncomelania* (Gredler), as described by Annandale (1924), was found in large numbers on the bank of a small pond. These were collected and brought to the laboratory, where about four hundred of them were crushed and examined for schistosome cercariæ, with negative results. About the same number of those remaining were then subjected to artificial infection by dropping them into a 250 cubic-centimeter glass cylinder, filled to the 250 cubic-centimeter mark with tap water, near the surface of which were numerous miracidia hatched from ova recovered from the stools of a schistosomiasis case. After a few minutes the snails began to climb the wall of the cylinder and, as they approached the surface of the water, they were seen through a hand lens to be attacked by the miracidia. As they came out of the water, they were picked up with a pair of forceps and dropped into a beaker, the bottom of which was filled with sand. The latter was kept constantly moist by the addition daily of small amounts of water. In such an environment the majority of the snails were kept alive for seven to eight weeks, after which they were crushed and examined for schistosome larvæ. About 4 per cent of them were found to harbor second-generation sporocysts (Plate 3, fig. 3) and fork-tailed cercariæ (Plate 4) morphologically identical with those of *Schistosoma japonicum*, as described by Cort (1919) and by Faust and Meleney (1924).

In the meantime search had been made in several other places, in many of which the same type of snail was encountered. Particularly along the banks of a small brook (Plate 1, fig. 2), near a house occupied by a schistosomiasis case and not far from the pond from which the first batch of snails was found, samples were collected nearly 2 per cent of which proved to be naturally infested with fork-tailed cercariæ also morphologically similar to the cercaria of the Oriental blood fluke.

IDENTITY AND HABITS OF THE MOLLUSK

The mollusk in question (Plate 2, fig. 3; Plate 5, fig. 1) is an operculate gastropod, which because of its small size and habits is apt to be overlooked by a casual collector. The smallest specimens average 3.45 millimeters in length by 1.85 millimeters in maximum diameter; the largest are 5.50 by 2.54 millimeters. The shell is smooth, acuminate, dextral, light to dark brown, but often discolored black, either partly or wholly. It possesses a maximum of six whorls, of which the terminal is often eroded. The operculum is ovate, thin, transparent, and with a large eccentric nucleus. The opening of the shell is also ovate, 1.60 to 2.04 by 1.00 to 1.30 millimeters in dimensions.

The snail has been identified as *Blanfordia quadrasi* (=*Prososthenia quadrasi* Möllendorf) by Dr. J. Bequaert, of Harvard University, to whom shells were submitted through the kindness of Dr. J. H. Sandground.[1] Compared with the other known intermediate hosts of *Schistosoma japonicum,* it most closely resembles *B. formosana* Pilsbry and Hirase, 1905. Through the courtesy of Drs. S. Yokogawa and H. Hirano, shells of the Formosan species came to hand, which when examined side by side with those of the Philippine form showed only slight differences (Plate 2, figs. 3 and 4).

The Philippine snail further agrees with the other species of *Blanfordia,* or *Oncomelania,* in its amphibious habits. It was very seldom encountered under water, but most frequently under dead leaves and other objects in moist surroundings above the edge of the water. It was also often seen attached to the stems and leaves of grasses and other weeds and to such objects as house and bridge posts, its position in every case being just a few millimeters above the surface of the water. It was never met with in the vicinity of principal rivers or their branches where the current is rapid, but seems to prefer small bodies of water where there is very little, if any, current. It appears to be a dirty feeder, for it was collected in largest numbers along the banks of a small mountain brook, a pond, a terminal irrigation canal, and irrigated rice paddies, where there are houses and where the presence of human fæces was very apparent (Plate 1). Like *B. nosophora,* the carrier of schistosomiasis in Japan, according to Cort (1919), the Philippine mollusk can withstand prolonged desiccation, at least up to four weeks under laboratory conditions.

INFECTION EXPERIMENTS

In order to establish definitely the identity of the cercariæ found in the snails, infection experiments were carried out while I was still in Palo and after my return to Manila. The animals used, consisting of five mice, one rabbit, and one Philippine monkey, were determined by the repeated examination of their fæces to be free from schistosome infection when the experiments were started. The mice in particular were bred under laboratory conditions that precluded any possible chance of their previously contracting the disease. With the exception of the monkey, the animals were infected by allowing them to stand in a vessel of water, about an inch deep, containing mature cercariæ from one or more snails. In the case of the monkey, besides immersing the fingers of one hand and the tip of the tail, cercaria-infected water was introduced into the mouth with a medicine dropper.

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[1] After sending the manuscript of this paper to the printer, a letter was received from Dr. Bernhard Rensch, of Berlin, by Dr. L. A. Faustino, of the Bureau of Science, who had forwarded shells of the snail to the Berlin Museum without knowing that I had sent specimens to Doctor Bequaert for determination. According to Doctor Rensch the mollusk in question represents a new species of *Oncomelania* and will be described by him in a coming issue of the Philippine Journal of Science.

Experiment 1.—February 8, 1932. Three mice were immersed for one hour in water containing cercariæ from one snail. March 1, or twenty-two days from the date of infection, the three mice were killed and there were collected from the mesenteric and hepatic veins of two of them 17 and 13, respectively, sexually immature female schistosomes.

Experiment 2.—February 13, 1932. Two mice were immersed for fifteen minutes in water containing cercariæ from one snail. March 11, or twenty-seven days from the date of infection, the mice were killed; one yielded 57 and the other 86 schistosomes. After fixation and staining, all of the parasites were determined to be males (Plate 3, fig. 4).

February 23, 1932. One monkey and one rabbit were infected with cercariæ derived from four snails. Beginning April 4, or forty-one days from the date it was infected, the monkey began to pass fæces coated with mucus and blood, which on examination under the microscope revealed the presence of the characteristic mature egg of *Schistosoma japonicum* (Plate 3, fig. 1).

April 13, or fifty days from the date it was infected, the rabbit was killed and yielded 700 mature or nearly mature schistosomes, of which 180 were in copula (Plate 5, fig. 2).

IDENTITY OF THE PHILIPPINE SCHISTOSOME

In view of the fact that the diagnoses of the schistosomiasis cases that have so far been seen in the Philippines were exclusively based on the finding of the eggs either in the stools or in sections of diseased tissues, some doubt has been held as to the specific identity of the causative agent. For this reason the various stages of the Philippine parasite have been compared very carefully with the descriptions of the corresponding stages of *Schistosoma japonicum,* as given by Katsurada (1904), Cort (1919, 1921), and Faust and Meleney (1924). Since no important differences have been found, the conclusion is, as has long been claimed, that the blood fluke infecting human beings in the Philippines is identical with that found in Japan, China, and Formosa.

ACKNOWLEDGMENT

In conclusion I desire to express my appreciation for the assistance rendered in the collection and examination of snails by Messrs. Simplicio Garcia and Andres Celestino, who accompanied me to Leyte. I also wish to thank Messrs. Juan Pacheco, municipal president, and José Acevedo, of Palo, for their valuable coöperation in various ways; Prof. S. Yokogawa, of Formosa, and Lieut. Col. Hiyashi Hirano, of the Imperial Japanese Army, for presenting me shell specimens of *Blanfordia formosana;* Dr. J. Bequaert for kindly identifying the snail shells submitted to him; and Drs. C. Africa, W. de Leon, C. Manalang, and J. Ira Concepcion for making available their unpublished records of schistosomiasis cases.

SUMMARY

1. The existence of schistosomiasis japonica in the Philippines was reported for the first time in 1906 by Wooley.
2. The disease seems prevalent in certain regions of the Islands, especially in Samar, Leyte, and Mindanao, judging from the number and distribution of the cases that have since been found.
3. The molluscan intermediate host of the causative agent of the disease, *Schistosoma japonicum,* had, however, not been identified in the Philippines.
4. A survey was, therefore, made in the town of Palo, Leyte, for the purpose of searching for the responsible mollusk.
5. As a result, a snail, which has been identified as *Blanfordia quadrasi* (=*Prososthenia quadrasi* Möllendorf), was found in moist places on the banks of small bodies of fresh water.
6. Samples of the snail collected near houses occupied by persons with schistosomiasis were found naturally infected with fork-tailed cercariæ that are similar in every respect to the cercaria of *Schistosoma japonicum.*
7. Mice and other laboratory animals were successfully infected with these cercariæ, the adult schistosomes collected from these animals being also morphologically identical with the adult *Schistosoma japonicum.*
8. The snail was further proven to be the intermediate host of the Oriental blood fluke by successfully infecting it with the miracidia of the parasite.

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ILLUSTRATIONS

[Plate 5, fig. 1, was drawn by Mr. A. Gonzales; the other drawings by Mr. V. V. Marasigan.]

ABBREVIATIONS USED

ac, acetabulum.
cg, cephalic gland.
d, cephalic gland duct.
ed, excretory duct.
ep, excretory pore.
ga, genital anlage.
gc, gynecophoral canal.
hg, head gland.
int, intestine.
Roman numerals refer to flame cells of cercaria.
mo, mouth opening.
od, oviduct.
oe, oesophagus.
ov, ovary.
sg, shell gland.
t, testis.
ut, uterus.
vd, vitelline duct.
vit, vitellaria.

PLATE 1

FIG. 1. A terminal irrigation canal. On its banks as well as on the posts of houses under which it passes, *Oncomelania* (*Blanfordia*) snails were found.

2. View of the brook where *Oncomelania* (*Blanfordia*) snails naturally infected with the cercaria of *Schistosoma japonicum* were collected. The house of a schistosomiasis case is very close to this portion of the brook.

PLATE 2

FIG. 1. A case of schistosomiasis japonica with distended abdomen and œdema.

2. Two brothers with schistosomiasis. The elder presents an enlarged liver, while the younger one shows marked ascites.

3. The intermediate host of *Schistosoma japonicum* in the Philippines, *Blanfordia quadrasi* (Möllendorf). × 5.

4. *Blanfordia formosana*, the intermediate host of *Schistosoma japonicum* in Formosa. × 5.

PLATE 3. SCHISTOSOMA JAPONICUM

FIG. 1. A mature egg as found in fæces. It incloses a fully-developed miracidium.

2. An immature egg in the uterus showing the small spine on the shell that is characteristic of this species.

3. A secondary sporocyst filled with cercariæ.

FIG. 4. A male worm, 27 days old, showing the presence of seven testes, dorsal view.

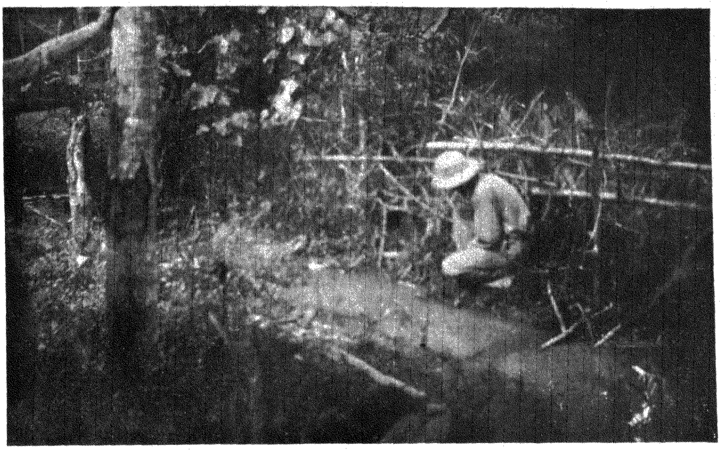
5. Details of the female reproductive organs.

PLATE 4. The cercaria of *Schistosoma japonicum*, ventral view.

PLATE 5

FIG. 1. *Blanfordia quadrasi* (Möllendorf), intermediate host of *Schistosoma japonicum* in the Philippines; *a*, lateral view; *b*, ventral view.

2. *Schistosoma japonicum*, adult male and female, in copula, lateral view.



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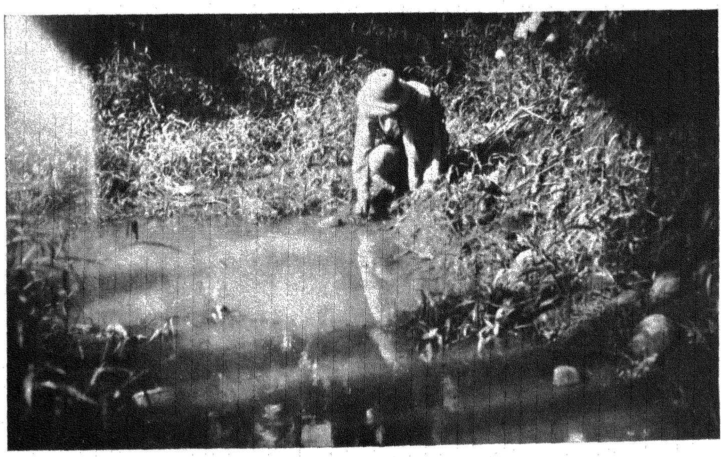

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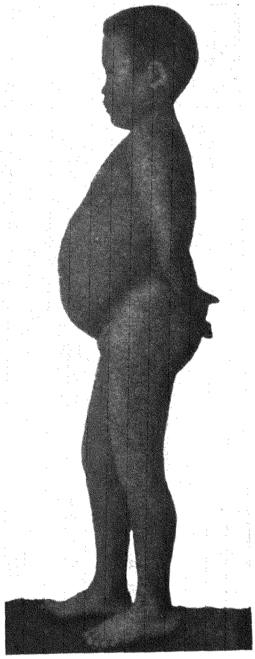

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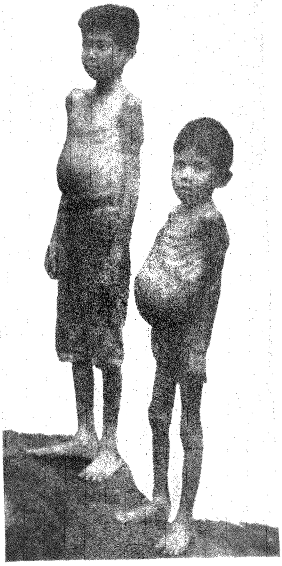

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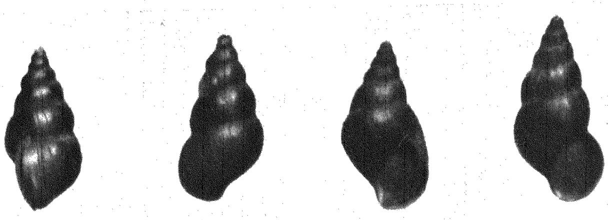

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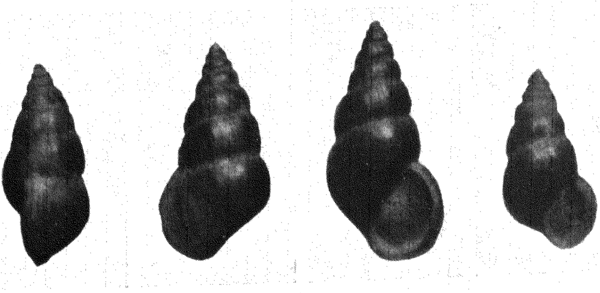

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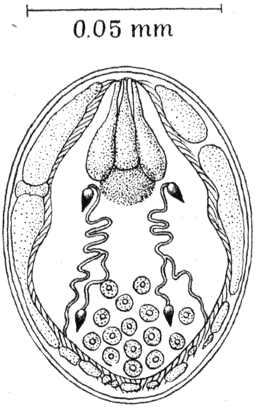

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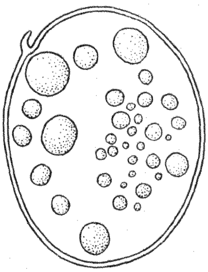

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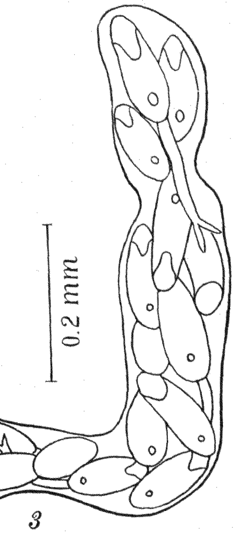

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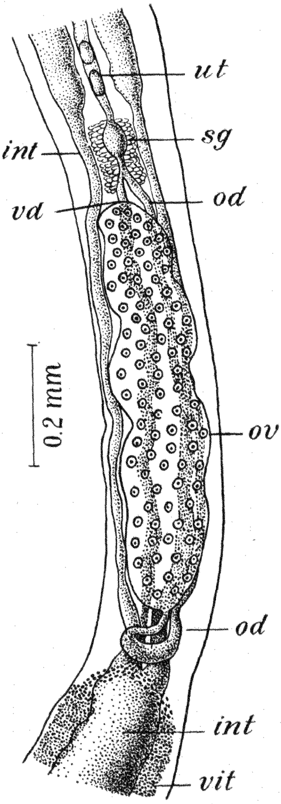

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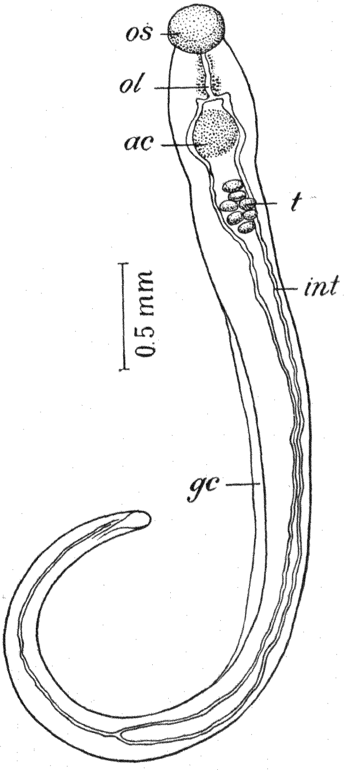

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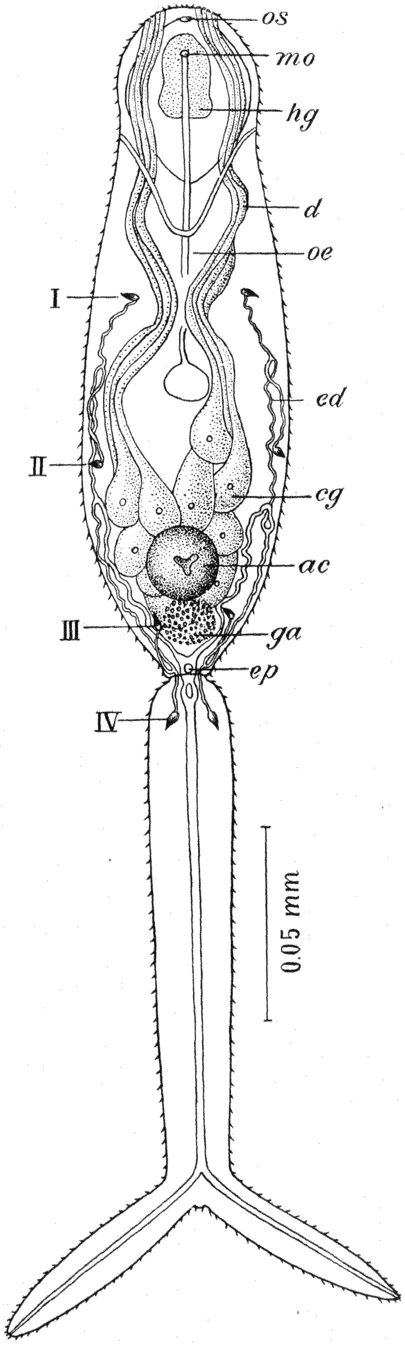

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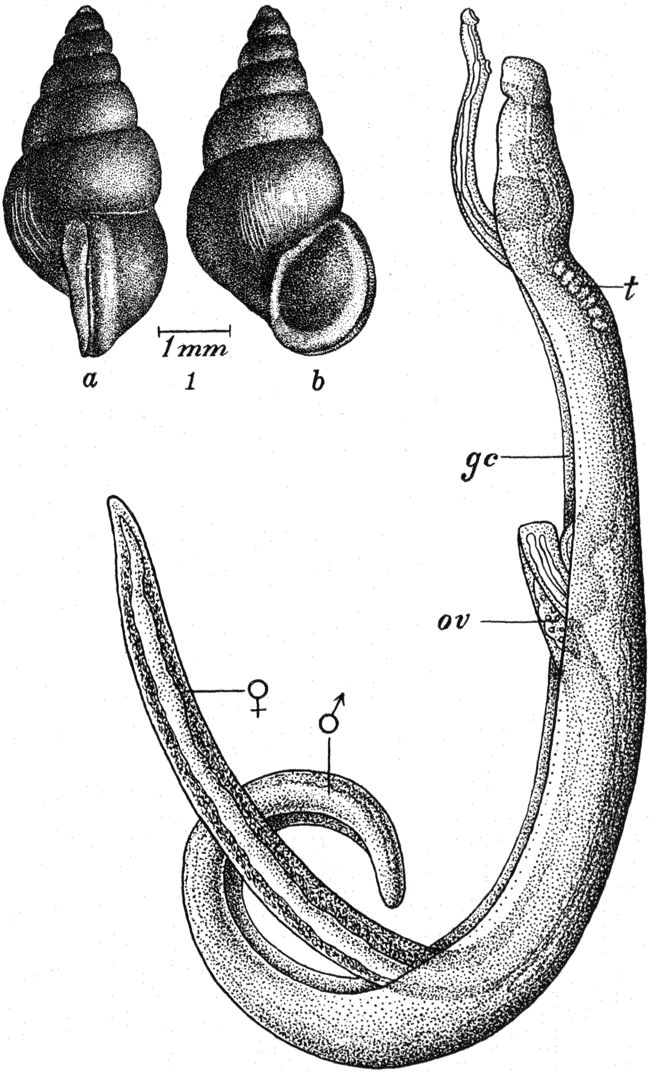

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PLATE 5.

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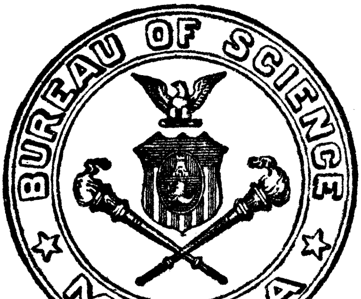

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THE PHILIPPINE JOURNAL OF SCIENCE

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MALARIA AND ANOPHELES RECONNAISSANCE IN THE PHILIPPINES [1]

By RUFUS L. HOLT

Of the United States Army Medical Department Research Board, Manila

and

PAUL F. RUSSELL

Of the International Health Division of the Rockefeller Foundation
Chief, Malaria Investigations, Bureau of Science, Manila

SEVEN PLATES AND ONE TEXT FIGURE

INTRODUCTION

The inception of this project was in November, 1930, and resulted from the request of the Headquarters, Philippine Department, United States Army, for more-definite information with regard to the prevalence of malaria in order that maneuvers

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[1] The surveys and laboratory studies on which this paper is based were made under the joint auspices of the Medical Department Research Board of the United States Army, the International Health Division of the Rockefeller Foundation, and the Bureau of Science of the Philippine Islands.

The authors are very greatly indebted to Dr. W. V. King, of the United States Bureau of Entomology, who is classifying the anophelines of the Philippines under the sponsorship of the International Health Division of the Rockefeller Foundation. All mosquito collections, after our identifications, were given to Doctor King for his collection. He has very kindly checked the identifications, especially of the *minimus-funestus* group.

The authors are no less indebted to Col. H. H. Rutherford, Department Surgeon, Philippine Department, for his great interest and support in the accomplishment of this work.

They are also indebted to Maj. John H. Kintner, Veterinary Corps, United States Army, for valuable assistance rendered in the survey of might be held in certain areas with minimum danger from infection by malaria. Other surveys followed in the order shown in Table 1.

TABLE 1.—*Itinerary and distance of reconnaissance surveys.*

Month and year.	Region.	Distance traveled.
		Km.
November, 1930	Bataan, east coast	272
December, 1930	Misamis	2,260
May, 1931	Corregidor and outposts	81
July, 1931	Bataan, central and west coast	337
July and August, 1931	Zambales	374
September and October, 1931	Kabasalan, Zamboanga	2,565
October, 1931	Bataan, east central	248
Do.	Pampanga and Tarlac	328
November, 1931	Tayabas	543
December, 1931	Laguna and Batangas	400
Do.	Mountain Province	715
January, 1932	Ilocos, La Union, Pangasinan, and Zambales	1,722
January and February, 1932	Mindanao and Sulu	4,597
February, 1932	Visayan and Bicol provinces	2,046
March, 1932	Northeastern provinces, Luzon	2,184
January to March, 1932	Laguna	538
March, 1932	Cavite and Rizal	418
Do.	Visayas	2,180
Do.	Palawan and Balabac	2,145
Various dates	Miscellaneous (including Baguio)	600
Total		24,553

In Table 1 are given the dates of surveys, places visited, and distances traveled in kilometers. It will be noted that the total distance was 24,553 kilometers. Means of transportation included foot, carabao carts, riding horses, various horse-drawn

Corregidor and its outlying posts, as well as assistance rendered in the completion of data.

Thanks are due to Loyd Stevens, sergeant, Medical Department, United States Army, Andres Nono, chief field inspector, malaria investigations, and Domingo Santiago, field inspector, malaria investigations. Further, we would express our thanks to the Director of the Bureau of Education and to many of the division superintendents and their teachers, who made possible spleen palpations in the schools and who at all times gave us their hearty coöperation. We are also grateful to the Director of the Bureau of Commerce and Industry who arranged for us to make one inspection trip on the cutter *Bustamante*. For data regarding altitudes we are indebted to the Director of the Bureau of Forestry. At various times officials of the Philippine Health Service lent their coöperation, for which we make due acknowledgment. Finally, we would acknowledge our indebtedness to the Director of the Bureau of Science for his assistance in planning this paper and in its publication.

vehicles, motor trucks and cars, bancas, launches, steamers, Government cutters, and railways. Table 2 lists all places in which spleen surveys and/or *Anopheles* collections were made.

TABLE 2.—*Places visited on malaria reconnaissance.*

- Abra Province.
  - Bangued.
  - Palao.
- Albay Province.
  - Bogtong.
  - Daraga.
  - Guinobatan.
  - Legaspi.
  - Mauraro.
- Antique Province.
  - Pandan.
- Bataan Province.
  - Abucay.
  - Bagac.
  - Balanga.
  - Cabcaben.
  - Corregidor.
  - Cupang.
  - Dinalupihan.
  - Hermosa.
  - Limay.
  - Mariveles.
  - Orani.
  - Orion.
  - Samal.
  - Sisiman.
- Batangas Province.
  - Cuenca.
  - Batangas.
  - Ibaan.
  - Rosario.
  - Sabang.
  - Tuy.
- Bulacan Province.
  - Baisa.
  - Malolos.
  - Marilao.
- Bohol Province.
  - Agricultural Colony.
  - Balilihan.
  - Calape.
  - Carmen.
  - Leon.
  - Tagbilaran.
- Cagayan Province.
  - Aparri.
  - Gattaran.
  - Iguig.
  - Tuguegarao.
- Camarines Sur Province.
  - Lagonoy.
  - Naga.
  - Pasacao.
- Capiz Province.
  - Buntog.
  - Capiz.
  - New Washington.
- Cavite Province.
  - Indang.
  - Naic.
  - Ternate.
- Cebu Province.
  - Cebu.
  - Labangon.
  - Mambaling.
  - Mandaue.
  - Tabunoc.
  - Toledo.
- Davao Province.
  - Davao.
  - Katitipan.
  - Matina.
  - Mintol.
  - Pakiputan.
  - Talomo.
  - Tugbok (Gulanga).
- Ilocos Norte Province.
  - Bacara.
  - Badoc.
  - Bangui.
  - Batac.
  - Laoag.
  - Paoay.
  - San Mateo.
- Ilocos Sur Province.
  - Bantay.
  - Cabugao.
- Ilocos Sur Province—Continued.
  - Suyo.
  - Vigan.
- Iloilo Province.
  - Iloilo.
  - Jaro.
  - Leon.
  - Passi.
- Isabela Province.
  - Echague.
  - Ilagan.
- Laguna Province.
  - Bay.
  - Biñan.
  - Cabuyao.
  - Calamba.
  - Calauan.
  - Dayap.
  - Lilio.
  - Longos.
  - Los Baños.
  - Luisiana.
  - Lumban.
  - Mabitac.
  - Magdalena.
  - Majayjay.
  - Nagcarlan.
  - Paete.
  - Pagsanjan.
  - Pila.
  - Santa Cruz.
  - San Juan.
  - San Pablo.
  - Santa Maria.
  - Santa Rosa.
  - Siniloan.
- Lanao Province.
  - Kolambugan.
- La Union Province.
  - Bauang.
  - Burgos.
  - Saitan.
- Leyte Province.
  - Carigara.

TABLE 2.—*Places visited on malaria reconnaissance*—Continued.

- Leyte Province—Ctd.
    - Talibong (Biliran Island).
- Manila, City of.
    - Malacañang.
    - Malate.
    - Maypajo.
- Masbate Province.
    - Masbate.
    - Tagba.
- Mindoro Province.
    - Camboag (San Jose).
    - Caminawit (Mangarin).
    - San Jose.
- Misamis Province.
    - Cagayan.
    - Gingoog.
- Mountain Province.
    - Baguio.
    - Cervantes.
    - Hapao.
    - Loo.
    - Tawan.
- Nueva Ecija Province.
    - Bongabon.
    - Cabiao.
    - Cabu.
    - Puncan.
    - San Jose.
- Nueva Vizcaya Province.
    - Bagabag.
    - Bambang.
    - Bayombong.
    - Rosario.
    - Santa Fe.
- Occidental Negros Province.
    - Bacolod.
    - Isabela.
    - Murcia.
    - San Carlos.
- Oriental Negros Province.
    - Dumaguete.
- Palawan Province.
    - Baja Point (west coast).
    - Balabac.
    - Coron.
    - Culion.
    - Cuyo.
    - Iwahig.
    - Puerto Princesa.
- Pampanga Province.
    - Del Carmen.
    - Floridablanca.
    - Fort Stotsenburg.
    - La Mitra.
    - Porac.
- Pangasinan Province.
    - Alaminos.
    - Infanta.
    - Lingayen.
    - Mabini (Balincaguin).
    - Malasiqui.
    - Urdaneta.
- Rizal Province.
    - Antipolo.
    - Las Piñas.
    - Navotas.
    - Parañaque.
    - San Francisco del Monte.
    - San Juan del Monte.
- Samar Province.
    - Allen.
- Sorsogon Province.
    - Bulusan.
    - Putiao.
    - Rizal.
    - Sorsogon.
- Sulu Province.
    - Astorias.
    - Bato-bato.
    - Bongau.
    - Jolo.
    - Lapac.
- Sulu Province—Ctd.
    - Lugus Island.
    - Maimbung (Jolo).
    - Manubul Island.
    - Pantao (Jolo).
    - Siasi.
    - South Ubian.
    - Tabo-tati (Jolo).
    - Tandu Bato (Jolo).
    - Tandu Patong (Jolo).
- Tarlac Province.
    - Luisita.
    - San Miguel.
- Tayabas Province.
    - Atimonan.
    - Candelaria.
    - Gumaca.
    - Lucban.
    - Lucena.
    - Malicbuy.
    - Mauban.
    - Pagbilao.
    - Sampaloc.
    - Sariaya.
    - Tayabas.
    - Tiaong.
- Zambales Province.
    - Candelaria.
    - Castillejos.
    - Iba.
    - Olongapo.
    - San Antonio.
    - San Felipe.
    - San Marcelino.
    - San Narciso.
    - Santa Rita.
    - Subic.
- Zamboanga Province.
    - Kabasalan.
    - Limajon (east coast).
    - Mercedes.
    - Talungatung.
    - Tumaga.
    - Zamboanga.

A number of malaria and *Anopheles* surveys have been reported from the Philippines. The first and most extensive of previous reports was that of Barber et al.(1) These observers visited fourteen provinces making collections of *Anopheles* larvæ. They also reported a total of 4,113 blood-smear examinations in children with a parasite index of 11.0 per cent and a total of 5,426 spleen examinations with a splenic index of 13.3 per cent.

Other surveys of special interest have been reported by Nichols,(2) Musgrave et al.,(3) Padua,(4, 5, 6) Manalang,(7, 8) Tiedeman,(9) Ejercito,(10,11) Mieldazis,(12) Ejercito and Laurel,(13) Holt and Russell.(14) Some of the information published in the last-cited report is included in this. G. F. Lull,(15) who was Medical Advisor to the Governor-General at the time of his report, gives the following figures for the mortality of malaria in the Philippine Islands (Table 3).

TABLE 3.—*Malaria in the Philippines, from Lull.*

Year.	Deaths.	Death rates for 100,000 population.	Year.	Deaths.	Death rates for 100,000 population.
1904	33,655	588.34	1918	38,322	411.42
1905	41,446	661.89	1919	37,726	398.00
1906	23,973	472.64	1920	29,653	308.00
1907	22,610	352.97	1921	28,407	281.78
1908	23,487	364.90	1922	27,196	257.74
1909	25,751	378.12	1923	24,142	218.14
1910	26,359	359.68	1924	26,740	232.94
1911	28,181	370.15	1925	24,329	218.39
1912	27,229	345.99	1926	24,318	210.63
1913	18,526	229.62	1927	19,520	166.32
1914	20,285	246.92	1928	15,925	133.78
1915	24,826	297.21	1929	15,332	127.02
1916	26,088	307.19	1930 [a]	15,144	123.61
1917	29,074	317.75	1931 [b]	11,787	94.89

[a] Figures for 1930 and 1931 were supplied by the Director of the Philippine Health Service.

[b] Figures for 1931 are provisional.

Ash,(16) in 1922, conducted a spleen survey along the eastern shore of Bataan examining 662 children in the area between Mariveles and Guagua, finding 128 children with enlarged spleens, all of which were south of Orion, Bataan.

Simmons and St. John(17) made a malaria survey on Corregidor in July, 1928, during which they examined 1,740 children, finding a splenic index of 3.6 per cent with 74.2 per cent correlation between positive spleens and parasites in the blood. The same authors with Reynolds(18) conducted a similar survey at Fort Stotsenburg, Pampanga, examining 993 children and finding 2.2 per cent with enlarged spleens. Of the positive spleen cases, 96 per cent were found to be harboring malaria parasites in the blood.

In view of the fact that none of the above-mentioned surveys included a majority of the provinces of the Philippines and because there has recently been an extensive revision in the classification of the local species and varieties of *Anopheles*, it seemed highly desirable to make a reconnaissance survey, first to determine in general the distribution of the various anophelines throughout the entire Archipelago, and second, to find out whether or not malaria is an island-wide problem. The present survey required eight months of nearly continuous travel in addition to numerous shorter surveys and gathered data from forty-one of the forty-eight provinces.

The survey party usually consisted of the authors, each with an assistant, but at times numbered eight persons. It was impossible, in the time available, to visit Romblon, Marinduque, and Camarines Norte Provinces and to penetrate the central portions of Mindanao, Mountain Province, Samar, and Leyte. Our itinerary is given in Table 1 and a list of places visited in Table 2.

GENERAL CONSIDERATIONS

The Philippine Islands extend from Sibutu, latitude 4° 40′ north, to Y'Ami, latitude 21° 5′ north, or about 1,100 miles. The Archipelago comprises 7,083 islands of which about 2,500 are named. The area of the group is about 114,000 square miles, a little less than the British Isles. Luzon and Mindanao comprise more than half of the area of the total. About 13,000,000 people inhabit the Islands according to latest official estimates.

Climate, rainfall, and average temperature conditions in the Philippines are shown by Plates 1 and 2, and no further discussion of these subjects is necessary in this paper.

As Craig(19) first pointed out, malaria in the Philippines is found in the foothills. As will be seen from Table 4, our experience bears this out. We have not found malaria on the coastal plains, on the plateaus, or in the mountains above 2,000 feet; but except for this fact that malaria transmission apparently does not occur above 2,000 feet, altitude per se, we believe, has little influence on the prevalence of malaria. It is change in altitude which has a direct and fundamental influence on malaria in the Philippines (see Table 4).

TABLE 4.—*Showing noneffect of altitude per se on malaria rates in selected places.*

Altitude.	Town and province.	Spleen index.
Feet.		
20 or less	Navotas, Rizal	3.0
	Abucay, Bataan	4.9
	Legaspi, Albay	6.4
	Dinalupihan, Bataan	30.6
	Siniloan, Laguna	33.7
	Bangui, Ilocos Norte	41.3
	Gattaran, Cagayan	61.8
30–100	Iguig, Cagayan	5.7
	Pagbilao, Tayabas	7.8
	Cabugao, Ilocos Sur	33.7
	Santa Maria, Laguna	57.0
100–200	San Miguel, Tarlac	6.0
	La Mitra, Tarlac	8.0
	Castillejos, Zambales	10.5
	Palao, Abra	22.4
	Echague, Isabela	38.1
300–500	Rosario, Batangas	13.7
	San Jose, Mindoro	26.5
	Suyo, Ilocos Sur	35.0
500–1,500	Cuenca, Batangas	14.0
	Saitan, La Union	22.8
	Bagabag, Nueva Vizcaya	90.0
Over 2,000:		
3,250	Hapao, Mountain	0.0
5,150	Loo, Mountain	0.0

SPLEEN RECONNAISSANCE

It should not be necessary at this date to write an apologia for the use of splenic enlargement as an index to the distribution and prevalence of malaria in a community, but doubt still creeps into the literature and has been locally expressed. Therefore, a brief review of the situation seems to be indicated.

Since the time of Sydenham,(23) and doubtless before, the relation between enlarged spleen and ague has been known. For at least eighty-five years this relationship has been used as a clue to the presence and prevalence of malaria in a community. Dempster(24) in India appears to have been first to show that this positive correlation between a large spleen and malarial fever is of practical value as a measure of malarial endemicity. He wrote that localities "free from splenic disease may be confidently selected as a good position for European and native troops." He concluded that "however healthy a locality may appear in other respects, if its native inhabitants are generally afflicted with organic disease of the spleen, there, beyond all doubt, does much malaria exist * * *." Hundreds of reported spleen surveys from every continent have amply borne out this clear-cut statement of 1847.

The spleen index is rapidly taken, causes little disturbance, and is probably more reliable as indicating the average prevalence of malaria than the blood index. We have seen no evidence that the spleen index is any less useful as an indication of malaria distribution and prevalence in the Philippines than elsewhere. We agree with Christophers(25) that "the ease with which it can be ascertained over large areas and for large numbers makes it a unique index in the measurement of disease, and to the malariologist it is one of the most precious assets of his science."

In view of attempts to depreciate the value of the spleen survey it must be kept in mind that malaria is not easily and accurately measured by any test. The plasmodia have the habit of secreting themselves in the recesses of spleen and bone marrow so that a negative blood smear may mean very little. As Manson(26) was wont to say, "what is found in the peripheral blood in malaria represents only an overflow from much greater visceral happenings. The splenic enlargement is one result of such happenings and is as important a measure of the malaria incidence as the microscopical examination of one thin film of blood."

Other references could be quoted; for example, that of Ross, Christophers, and Perry(27) who, on the basis of very extensive experience, wrote that the spleen rate is the "most readily and extensively applicable, and at the same time the most reliable measure of the amount of malaria in a community * * *."

As regards the Philippines, the most extensive spleen survey in the past was that of Barber et al.(1) who made 5,426 spleen and 4,646 blood smear examinations in fourteen provinces. They found a parasite index of 11 per cent and a spleen index of 13.3 per cent. Of the 3,686 children who had both spleen and blood examinations, 7.5 per cent were positive for parasites and 12.4 per cent for splenic enlargement. In communities in which at least one parasite-positive case was found, that is in malarious places, there were 1,883 spleen-negative cases among children and of these 7.7 per cent were parasite-positive. The authors state further, "of approximately 569 cases presenting enlarged spleens of whom the blood was examined, 164 or 28.8 per cent, were positive for parasites. It is well known that cases exhibiting splenomegaly, known to be the result of malaria, often fail to show parasites in the blood."

The authors conclude, "while a larger series than ours may be needed to solve this question, we believe that a spleen rate over 10 indicates present or past malaria in the most, if not all the communities of the Philippines. However, we should not recommend that the malarial survey of a locality should rest on the spleen examination."

Except that we believe spleen rates of more than 5 to have malarial significance, we agree, and feel that in any given locality accurate measurement of malaria requires both spleen and blood tests. In a reconnaissance such as we are reporting we feel confident that the spleen test alone is a fair indication of the presence or absence of malaria. We are not using it as more than a broad measure of local intensity and have not given any totals by provinces, believing that such totals should only be given where a province has been thoroughly surveyed.

It is well known that other diseases cause splenic enlargement and that the examiner must, therefore, be on the lookout for such acute infections as septicæmia, typhus and typhoid fevers, measles, chicken pox, mumps, erysipelas, acute miliary tuberculosis, tuberculous peritonitis, cerebrospinal meningitis, Malta fever, smallpox, diphtheria, scarlet fever, relapsing fever, and plague. These diseases are listed by Boyd(28) as producing acute enlargement of the spleen. This author further states that chronic enlargement, other than malarial, is observed in congenital syphilis, schistosomiasis, kala azar, leukemia, splenic anæmia, Gaucher's disease, malignant neoplasms, and familial jaundice. Lesser degrees of enlargement are present in cirrhosis of the liver, rickets, pernicious anæmia, passive congestion, and acute portal obstruction.

This is an imposing list, but in practice in the Philippines in spleen examinations in schools and public places—that is, not in hospitals, dispensaries, or homes—confusion may arise only from measles, chicken pox, and, in some regions, schistosomiasis. During our survey we encountered both measles and chicken pox. With regard to measles and chicken pox our experience has been in line with the reports by Boyd.(28) Splenic enlargement in these diseases does not become chronic. By the time the rash has faded, the spleen is usually not palpable even on deep inspiration. In our tables these cases, giving evidence of recent chicken pox or measles, have been excluded.

According to a recent survey by Tubangui,(29) there are foci of schistosomiasis in Leyte. We found no cases in our brief visits at the northern end of this island and saw none elsewhere, but the disease unquestionably is fairly prevalent in the areas visited by Tubangui and must be kept in mind in spleen surveys in the Philippines.

In technic of examination we have used wherever possible the more delicate method of Darling.(30) The child is placed in a recumbent position with the thighs and legs flexed. The clothing is loosened so that the hand of the examiner can be placed upon the bare skin of the abdomen in the region of the spleen at the costal margin. Standing on the child's right, the examiner gently explores the upper left quadrant of the abdomen with the finger tips, feeling for an enlarged spleen. If the spleen is not palpable, the child is instructed to take a deep breath. The tips of the fingers of the examiner's right hand are held at and just below the costal margin. As the child breathes deeply, slight pressure is made with the fingers and sometimes a spleen, pushed down by the diaphragm, becomes palpable.

Having palpated a spleen it may be classified as to size according to one of several systems. These vary from the simple but satisfactory finger's breadths of the earlier malariologists to the latest method of triangulation of the position of the apex of the spleen by measurement of its distance in centimeters from the umbilicus and from the median line of the body, with corrections for the age and size of the child. This refined technic of Christophers(31) is particularly useful in quantitative and comparative studies of community spleen mass and is certainly the most accurate of all devices for recording spleen sizes. It has no place, however, in a reconnaissance, for it is a burdensome and slow process. Furthermore, in the Philippines, it could usually be applied only to boys. There has been no objection from girls or their parents, to a simple palpation of the child's spleen, hand on skin, without exposure, in the schoolroom. Exposure usually would not be tolerated. Therefore, in our survey we have not attempted meticulous measurements. In a few localities it was necessary to examine children in the standing position because of their shyness. These exceptions are duly noted in the table which summarizes the results.

We have classified our spleens in six groups as follows, after Boyd:(28)

Spleen 0. Spleen not palpable.
Spleen P. D. I. Palpable only on deep inspiration.
Spleen 1. Palpable at the costal margin on normal respiration.
Spleen 2. Palpable, extends halfway to the umbilicus.
Spleen 3. Palpable, extends to the umbilicus.
Spleen 4. Palpable, extends beyond the umbilicus (see fig. 1).

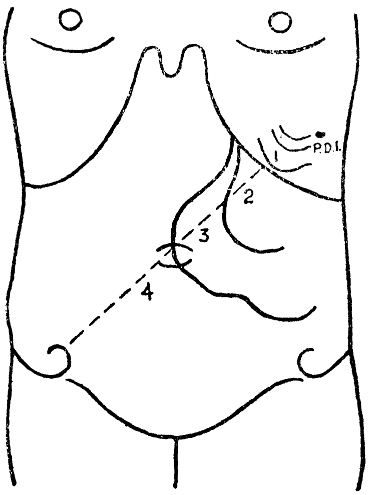

FIG. 1. Diagram of spleen sizes according to Boyd.

The interpretation of these groups is of course open to question. The negative group undoubtedly includes some cases of malaria. This is evident not only from the discussion above but from the study of Oudendal.(32) This author, in a series of cases, made both ante- and post-mortem spleen examinations with the results shown in Table 5.

Oudendal concluded logically that many factors influenced the palpability of the spleen, such as its length, width, thickness, consistency, and weight. Also the position of the diaphragm, the status of the abdominal wall and abdominal cavity, the direction of the longitudinal splenic axis, and the deftness of the palpating hand. So the absence of a palpable spleen cannot always be considered conclusive evidence of an absence of malaria.

TABLE 5.—*Spleen weights from Oudendal.*

Spleen weight post mortem.	Number examined.	Palpable ante mortem.	
		No.	Per cent.
g.			
110-250	165	24	14.5
250-400	103	41	37.7
400-870	87	51	58.7
870-2,147	28	27	96.4

As to the significance of the spleens palpable on deep inspiration, doubt has been expressed by some and confidence by others. Darling(30) was the first to use this class of spleens in the measurement of malaria. He believed that in regions of light endemicity the spleens just palpable on deep inspiration were of some value as an indication of malaria, although he recognized that this group must be used with discrimination as it undoubtedly includes spleens not malarious. But he believed that when intelligently interpreted the smallest palpable spleens as a class contributed definitely to the malaria picture.

One of us (P. F. R.) assisted in some studies in the Southern United States which seem to have borne out these contentions. As reported by Darling,(33) these showed first, that the palpable-on-inspiration spleens in negro children may show a high percentage of positive blood smears, as seen in Table 6.

TABLE 6.—*Spleens in negro children, from Darling.*

	Spleen group.					
	Negative.	Palpable on inspiration.	Palpable.	One finger's breadth.	Two fingers' breadth.	Three fingers' breadth.
Number	260	110	65	32	56	47
Positive blood films in each spleen group:						
Number	25	60	45	26	43	43
Per cent	9.6	54.5	69.2	81.3	76.8	91.5

Secondly, these studies showed that the palpable-on-inspiration spleens are affected by quinine. Darling estimated the weights of the different class spleens as follows:

	g.
Negative spleen	75
Palpable on inspiration	90
Palpable	105
One finger's breadth below costal margin	125
Two fingers' breadth below costal margin	150
Three fingers' breadth below costal margin	180
To umbilicus	220

These estimates were based in part on Bean's(34) studies. Using these estimates, Table 7 illustrates the effect of the Bass(35) standard quinine treatment on spleen size in forty-five negro children.

TABLE 7.—*Effect of Bass quinine treatment on spleen size in negro children.*

	Spleen size.					
	Palpable on inspiration.	Palpable.	One finger's breadth.	Two fingers' breadth.	Three fingers' breadth.	Umbilicus.
Number of cases	11	12	7	11	3	1
Weight before treatment g	11×90 990	12×105 1,260	7×125 875	11×150 1,650	3×180 540	1×220 220
Weight after 8 weeks' treatment g	945	1,140	660	1,145	375	90
Change in weight g	— 45	—120	—215	—505	—165	—130
Change in weight per person g	— 4	— 10	— 30	— 45	— 55	—90

In a control group of twenty-five negro children who had no treatment but were examined each time there were the changes shown in Table 8.

TABLE 8.—*Spleen size in untreated negro children.*

	Spleen size.					
	Palpable on inspiration.	Palpable.	One finger's breadth.	Two fingers' breadth.	Three fingers' breadth.	Umbilicus.
Number of cases	8	8	5	6	1	0
Weight before treatment g	720	840	625	900	180	--------
Weight after ten weeks (no treatment) g	720	835	480	905	150	--------
Change in weight g	0	— 5	—245	— 5	— 30	--------
Change in weight per person g	0	—0.6	— 49	—0.8	— 30	--------

For a complete analysis of these experiments see in addition to Darling,(33) also Collins.(36)

Another reason for believing that the palpable-on-inspiration spleens have malarial significance is the fact that they are not found to any extent in nonmalarial localities, but they are found in malarious places. The more malaria the greater the numbers of palpable-on-inspiration spleens. For example, one of us(37) examined one hundred twenty-one boys in Georgetown on Penang Island and found only four palpable-on-inspiration spleens, and none larger. In Permatang Imas Laut, where malaria was hyperendemic, twenty-eight palpable-on-inspiration spleens were found among a total of sixty enlarged spleens in sixty-six examinations. The largest spleen was of pelvic size, two were at the umbilicus, and nineteen were from one to four fingers' breadth in size.

In the present survey it will be noted, as shown in Table 9, that in Manila, Lingayen, Cebu, and Navotas, where malaria is not endemic, only eleven palpable-on-inspiration spleens were found in a total of four hundred three examinations in which there were only twelve enlarged spleens altogether, including those palpable on inspiration. In Bambang, Bangui, San Jose, and Bulusan, where malaria is endemic, thirty-three palpable-on-inspiration spleens were found among a total of one hundred twenty-seven enlarged spleens in two hundred fifty-one examinations.

Our present series of cases having both blood smear and spleen palpation is too small to carry much weight. However, it may be noted that of fourteen individuals having palpable-on-inspiration spleen, 9, or 64.3 per cent, also had positive blood smears.

We believe that this group of palpable-on-inspiration spleens in the Philippines has real value in a malaria reconnaissance. There are regions, like Ilagan, Isabela Province, where during the dry season the small streams become completely dry and practically speaking, malaria transmission ceases. During the wet season typical *A. minimus* breeding places abound and there is a "fever season." Our examinations were made in March when no anopheles larvæ could be found, in the middle of the dry period. We found fourteen palpable-on-inspiration spleens in eighty-four children. Only four other spleens were palpated. One was class 2 and three were class 1. Without the fourteen spleens in the palpable-on-inspiration group the splenic index is 4.5 per cent. With the small spleens included the index is 21.7 per cent. The former figure by itself is of no malarial significance yet includes definitely malarious spleens and is in a locality which has a definitely malarious season. The latter figure of 21.7 per cent is probably a much more reliable index as to the malarial status of Ilagan because it includes the residual spleens from the last malarial season. These small spleens, where numerous, probably represent chronic quiescent infections, although they may occasionally be indicative of recent but mild attacks, and of course may sometimes be without significance.

As to the significance of the larger spleens we are inclined to believe that MacDonald's(38) theories apply in a general way to the Philippines. Spleens of size 1 probably represent either recent active infections or chronic quiescent malaria. Size 2 spleens represent perhaps reinfections or relapses in those long infected. Sizes 3 and 4 are due to frequent reinfections in individuals whose tolerance is not yet well developed.

As to the belief that splenic enlargement is constant in tertian and quartan infections but variable in æstivoautumnal malaria, and that the two former produce a greater enlargement than the latter, we have insufficient data to express an opinion. See Stephens and Christophers.(39)

There was a total of 1,404 enlarged spleens among the 7,810 individuals examined. This is an index of 17.9 per cent. If we assume a population of 13,000,000 (this is the usual assumption at the present time in the various Government bureaus) this indicates roughly a malaria morbidity of 2,300,000. If we assume the usual prognosis, with a mortality of 1 per cent, we could expect a death rate from malaria in the Philippines of around 23,000. We believe this figure to be approximately correct. Undoubtedly, many deaths are incorrectly attributed to malaria, but it is equally true that many malaria deaths are not so reported.

The map shown as Plate 3 has been prepared to show in general these spleen findings. It will be noted that we have arbitrarily classified our spleen indices as follows:

Per cent.		
5 or less	Not significant	N. S.
6–10	Faint endemicity	F.
11–20	Mild endemicity	M.
21–30	Moderate endemicity	M.
31–50	Severe endemicity	S.
51 or more	Hyperendemicity	H.

Tables 9 and 10 represent, respectively, the findings by locality and size of spleen in the first instance, and age, sex groups, and size of spleen in the second instance. In these tables are included figures by Ash on Mariveles, Bataan, by Simmons, St. John, and Reynolds on Fort Stotsenburg, Pampanga, and by George C. Dunham on Bongau and Batobato, Sulu. The figures by Ash were compiled in 1922, by Simmons, St. John, and Reynolds, in 1929, and by Dunham, in 1932. Since the preparation of these tables we have secured our own figures on Mariveles. Of forty-eight children examined, we found only four palpable-on-inspiration spleens, or a positive per cent of 8.4, as against the findings by Ash of 31.6 per cent. In addition, we examined eleven children at Cabcaben, Bataan, and found one No. 3 spleen and five No. 1 spleens, a positive rate of 54.5 per cent.

TABLE 9.—*Spleen survey. By locality and size of spleen.*

Province and locality.	Population.	T.	Examined.	Negative.	Size of spleen.					Positive.	
					P. D. I.	1	2	3	4	Number.	Per cent.
Abra:											
Bangued	13,892	L	94	63	13	14	3	1		31	33.0
Palao	339	L	76	59	6	9	2			17	22.4
Albay:											
Bogtong	1,306	L	46	39	5	1	1			7	15.2
Legaspi	6,055	L	93	87	4	2				6	6.4
Mauraro	2,891	L	47	39	5	3				8	17.0
Antique:											
Pandan	16,226	L	115	97	9	9				18	15.7
Bataan:											
Abucay	7,347	L	102	97	3		1	1		5	4.9
Balanga	8,141	L	174	156	12		1	5		18	10.3
Corregidor	8,000	L	107	90	11	3	2	1		17	16.0
Dinalupihan	4,107	L	36	25	7		1	3		11	30.6
Hermosa	3,150	L	127	118	6		1	2		9	7.0
Limay	3,514	L	56	43	8		5			13	23.2
Mariveles	2,816	L	57	39						18	31.6
Orani	6,336	L	144	136	6		2			8	5.6
Orion	7,887	L	152	134	11		5	2		18	11.8
Samal	5,231	L	107	100	7					7	6.5
Sisiman	116	L	14	4		2	5	1	2	10	71.3
Batangas:											
Batangas	41,089	L	86	80	6					6	7.0
Cuenca	7,106	L	57	49	5	3				8	14.0
Rosario	22,174	L	51	44	5	2				7	13.7
Tuy	5,847	L	104	78	13	9	2	2		26	25.0

Cagayan:											
Aparri	20,603	S	24	22	1	1	------	------	------	2	8.3
Gattaran	7,009	S	34	13	1	11	4	4	1	21	61.8
Iguig	5,413	S	52	49	1	2	------	------	------	3	5.7
Tuguegarao	19,298	S	54	47	5	2	------	------	------	7	13.0
Camarines Sur:											
Lagonoy	12,681	L	57	46	6	5	------	------	------	11	19.3
Naga	9,396	L	56	50	4	2	------	------	------	6	10.7
Pasacao	2,308	L	71	46	13	8	2	2	------	25	35.2
Capiz:											
New Washington	24,453	L	89	87	2	------	------	------	------	2	2.3
Cebu:											
Cebu	65,502	L	89	87	2	------	------	------	------	2	2.3
Davao:											
Davao	13,300	L	82	79	2	1	------	------	------	3	3.7
Katitipan	89	S	21	21	------	------	------	------	------	------	0.0
Mintol	146	L	31	28	2	1	------	------	------	3	9.7
Tugbok	214	S	41	37	------	4	------	------	------	4	10.0
Ilocos Norte:											
Badoc	17,598	L	76	53	6	8	7	2	------	23	30.2
Bangui	10,654	L	80	47	7	18	5	3	------	33	41.3
Laoag	38,469	L	131	94	15	13	6	3	------	37	28.2
Ilocos Sur:											
Cabugao	12,025	L	95	63	11	15	4	2	------	32	33.7
Suyo	638	L	40	26	3	10	------	1	------	14	35.0
Vigan	17,765	L	52	48	3	1	------	------	------	4	7.7
Isabela:											
Echagüe	17,104	L	42	26	10	6	------	------	------	16	38.1
Ilagan	23,279	L	84	66	14	3	1	------	------	18	21.7
Laguna:											
Calauan	2,832	L	82	52	12	11	2	5	------	30	36.6
Magdalena	3,032	L	78	48	15	8	3	3	1	30	38.3
Pagsanjan	7,538	L	51	44	6	1	------	------	------	7	13.7
Santa Cruz	14,156	L	53	47	2	4	------	------	------	6	11.3

TABLE 9.—*Spleen survey. By locality and size of spleen*—Continued.

Province and locality.	Population.	T.	Examined.	Negative.	Size of spleen.					Positive.	
					P. D. I.	1	2	3	4	Number.	Per cent.
Laguna—Continued.											
Santa Maria	540	L	37	16	2	7	5	5	2	21	57.0
Siniloan	3,913	L	83	55	11	10	4	2	1	28	33.7
La Union:											
Bauang	12,952	L	50	43	7					7	14.0
Burgos	500	L	51	40	6	4	1			11	21.5
Saitan	550	L	63	48	6	8	1			15	23.8
Leyte:											
Carigara	17,558	L	86	72	7	6	1			14	16.3
Talibong (Biliran Island)	554	L	32	28	3	1				4	12.5
Manila:											
American School	285,306	L	40	39	1					1	2.5
Malate School		L	75	72	3					3	4.0
Masbate:											
Masbate	10,821	L	99	92	5	2				7	7.0
Mindoro:											
Camboag	60	S	7	0			1	2	4	7	100.0
Caminawet (Mangarin)	487	L	18	10	3	2	3			8	44.4
San Jose	7,703	L	78	38	9	13	5	6	7	40	51.3
Mountain Province:											
Hapao	1,000	S	10	10						0	0.0
Hungduan	1,000	S	3	3						0	0.0
Loo	2,000	S	51	51						0	0.0
Taiwan	500	S	15	15						0	0.0
Nueva Ecija:											
Bongabong	4,434	L	52	26	10	13	2	1		26	50.0
Cabu	209	L	47	35	6	4	2			12	25.5

Puncan	496	L	47	14	10	14	6	3	----	33	70.2
San Jose	834	L	49	36	9	4	----	----	----	13	26.5
Nueva Vizcaya:											
Bagabag	3,730	L	40	4	8	10	9	6	3	36	90.0
Bambang	2,564	L	47	8	10	17	6	3	3	39	83.0
Bayombong	5,627	L	40	7	15	12	2	3	1	33	82.5
Santa Fe	625	S	21	3	2	9	2	3	2	18	85.7
Pampanga:											
Floridablanca	8,477	L	50	47	2	1	----	----	----	3	6.0
Fort Stotsenburg	9,000	----	993	971	----	----	----	----	----	22	2.2
La Mitra	5,000	L	50	46	2	2	----	----	----	4	8.0
Porac	8,000	L	50	41	3	4	----	2	----	9	18.0
Pangasinan:											
Alaminos	14,353	L	54	44	3	6	1	----	----	10	18.5
Infanta	5,613	L	47	42	2	2	----	1	----	5	11.1
Lingayen	22,750	L	100	97	2	1	----	----	----	3	3.0
Mabini (Balincaguin)	4,760	L	50	36	6	6	2	----	----	14	28.0
Rizal:											
Navotas	13,454	L	99	96	3	----	----	----	----	3	3.0
Samar:											
Allen	8,497	L	47	34	6	5	1	1	----	13	27.7
Sorsogon:											
Bulusan	8,046	L	46	31	7	8	----	----	----	15	32.6
Putiao	614	L	42	37	5	----	----	----	----	5	12.0
Rizal	2,224	L	38	28	4	5	1	----	----	10	26.3
Sorsogon	16,694	L	94	86	7	1	----	----	----	8	8.5
Sulu:											
Bongau	1,979	L	40	34	----	----	3	3	----	6	15.0
Bato-bato	750	L	35	16	----	----	4	14	1	19	54.3
Jolo	5,810	L	74	62	3	8	1	----	----	12	16.2
Lapac	----	L	44	35	8	1	----	----	----	9	20.8
Lugus Island	4,800	L	123	99	11	9	2	2	----	24	19.5
Maimbung (Jolo)	1,950	L	36	23	7	3	2	1	----	13	36.1
Manubul Island	900	L	60	50	2	6	1	1	----	10	16.7
Pantao (Jolo)	220	L	12	7	2	2	----	1	----	5	41.7

TABLE 9.—*Spleen survey. By locality and size of spleen*—Continued.

Province and locality.	Population.	T.	Examined.	Negative.	Size of spleen.					Positive.	
					P. D. I.	1	2	3	4	Number.	Per cent.
Sulu—Continued.											
Siasi	245	S	76	66	--------	7	1	1	1	10	13.2
South Ubian Island	4,327	S	78	56	--------	11	4	7	--------	22	28.2
Tayabas:											
Atimonan	13,087	L	56	54	2	--------	--------	--------	--------	2	3.6
Lucban	12,913	L	50	48	1	1	--------	--------	--------	2	4.0
Lucena	12,108	L	49	46	--------	3	--------	--------	--------	3	4.1
Mauban	12,516	L	48	41	--------	2	3	2	--------	7	14.6
Pagbilao	6,879	L	77	71	2	3	--------	1	--------	6	7.8
Sampaloc	3,074	L	56	45	--------	6	4	1	--------	11	19.7
Tayabas	14,983	L	50	27	--------	6	10	7	--------	23	46.0
Zambales:											
Castillejos	4,000	L	38	34	1	2	1	--------	--------	4	10.5
Iba	5,452	L	45	34	5	5	1	--------	--------	11	24.4
San Antonio	5,164	L	56	53	1	1	1	--------	--------	3	5.4
Santa Rita	375	L	35	30	1	2	1	--------	1	5	14.3
Subic	14,159	L	50	46	2	1	1	--------	--------	4	8.0
Zamboanga:											
Kabasalan	2,350	L	144	81	--------	30	20	13	--------	63	43.7
Mercedes	2,765	L	65	54	7	3	--------	1	--------	11	17.0
Tulungatung	675	L	52	43	3	6	--------	--------	--------	9	17.3
Zamboanga	30,798	L	50	47	1	1	--------	1	--------	3	6.0
Total	----------	------	7,810	6,406	529	488	182	135	30	1,404	---------

TABLE 10.—*Spleen-survey totals. By age and sex groups and size of spleen.*

Group.		Examined.	Spleen size.												Total enlarged.	
			Negative.		P. D. I.		1		2		3		4			
Sex.	Age.		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Male	All	3,702	2,948	79.6	276	7.5	272	7.3	106	2.9	81	2.2	19	.5	754	23.7
Do	-1	9	4	4.4					2	22.2	3	33.3			5	55.5
Do	1-4	103	59	5.7	3	2.9	21	20.4	8	7.7	7	6.8	5	4.8	44	42.7
Do	5-9	2,637	2,133	80.9	201	7.6	168	6.4	72	2.7	54	2.0	9	.4	504	19.1
Do	10-19	942	742	78.8	71	7.5	83	8.9	24	2.5	17	1.8	5	.5	200	21.2
Do	20+	11	10	90.9	1	90.9									1	9.1
Female	All	2,855	2,267	79.4	244	8.5	205	7.2	74	2.5	54	1.9	11	.4	588	20.7
Do	-1	3	1	33.3							2	66.6			2	66.6
Do	1-4	89	56	62.9	2	2.2	15	16.9	5	5.6	8	9.0	3	3.4	33	37.1
Do	5-9	2,297	1,837	79.9	212	9.2	151	6.6	56	2.4	34	1.4	7	.3	460	20.0
Do	10-19	466	373	80.0	30	6.4	39	8.4	13	2.8	10	2.1	1	.2	93	20.0
Do	20+															
Total, male and female	-1	12	5	41.7					2	16.6	5	41.6			7	5.9
Do	1-4	192	115	60.0	5	2.6	36	18.7	13	6.8	15	7.8	8	4.2	77	40.1
Do	5-9	4,934	3,970	80.4	413	8.3	319	6.5	128	2.6	88	1.8	16	.3	964	19.5
Do	10-19	1,408	1,115	79.2	101	7.2	122	8.6	37	2.6	27	1.9	6	.4	293	20.8
Do	20+	11	10	90.9	1	9.1									1	9.1
Undetermined age and group		1,050	1,010	96.2											40	3.8
Undetermined age		203	181	89.1	9	4.4	11	5.4	2	.9					22	10.8
All		7,810	6,406	82.0	529	6.8	488	6.3	182	2.3	135	1.7	30	.4	1,404	17.9

These tables show a total of 7,810 children examined with a positive rate of 17.9 per cent, there being 1,404 positives in the total number examined. It will also be noted that the greatest number fell in the age group 5 to 9. This is due to the fact that children in the first and second grades of school were examined in the great majority of instances. Of the 1,408 falling in the age group 10 to 19, but few were over 12 years of age. The population figures are not accurate, since they were taken from the 1918 census report, the latest available. The "T" in Table 9 is the technic of examination, standing or lying. There appears to be but little difference in the rate as between the sexes but there was a higher percentage of positives among the younger age groups in both sexes.

PARASITE STUDIES

In Table 11 are listed the results obtained in the examination of 1,101 thin blood smears taken during our reconnaissance. Active antimosquito and antimalaria work is being carried out at Fort Stotsenburg and Fort Mills only. In no case were the smears taken from selected cases except at Hacienda Mataan where only those cases giving positive histories were selected. It seems evident that all cases at Fort Mills were contracted somewhere else since exhaustive search failed to show the presence of the vectors on Corregidor Island at the time the slides were taken. In the undetermined column are placed those undoubtedly positive but the type of which could not be determined. In all cases slides were examined for thirty minutes unless plasmodia were found sooner. It is evident that *P. malariæ* is rare and that *P. falciparum* and *P. vivax* are common at all places where examinations were made.

We had opportunity to secure but little evidence as to the correlation between spleen-positive and malaria-positive cases. In Table 12 are given the results in 104 cases. In each case a thin smear was used and thirty minutes consumed in examination unless found positive before thirty minutes' study. We realize that many positives were probably missed due to absence of plasmodia in the peripheral circulation. While only 14 palpable-on-inspiration spleens are included, it is striking that 64.3 per cent showed plasmodia in the peripheral blood. As other workers have found, the larger the spleen the more plasmodia positives did we find. In no case did we select for inclusion in the table any person for any other reason except that they had an enlarged

TABLE 11.—*Summary of blood-smear examinations.*

Place.	Date.	Examined.	*Plasmodium vivax.*		*Plasmodium falciparum.*		*Plasmodium malariæ.*		*Plasmodium vivax* and *P. falciparum.*	
			Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Kabasalan, Mindanao	Oct. 1, 1931	493	50	10.2	48	9.7			4	0.8
Gingoog, Mindanao	Dec. 5, 1930	271	56	20.7	50	18.5	4	1.5	11	4.1
Fort Stotsenburg, Pampanga	1930, 1931, 1932	187	5	2.7						
Fort Mills, Corregidor	June 14, 1931	107	14	13.1	4	3.7				
Hacienda Natib, Bataan	July 4, 1931	29	14	48.3	2	7.0	1	3.5		
Hacienda Mataan, Bataan	July, Nov., Dec., 1931	150	30	20.0	39	26.0			5	3.3
Total		1,237	169	13.6	143	11.6	5	0.4	20	1.6

Place.	Date.	*Plasmodium vivax* and *P. malariæ.*		All three parasites.		Undetermined.		Positive.		Negative.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Kabasalan, Mindanao	Oct. 1, 1931							94	19.1	399	80.9
Gingoog, Mindanao	Dec. 5, 1930			1	0.4	3	1.1	73	26.9	198	73.1
Fort Stotsenburg, Pampanga	1930, 1931, 1932							5	2.7	182	97.3
Fort Mills, Corregidor	June 14, 1931							18	16.8	89	83.2
Hacienda Natib, Bataan	July 4, 1931	1	3.5					16	55.2	13	44.8
Hacienda Mataan, Bataan	July, Nov., Dec., 1931							74	49.3	76	50.7
Total		1		1		3	0.3	280	22.6	957	77.4

spleen. No conclusions can be drawn due to the small number of cases, but the table is reproduced in order that it may be included with other findings of the same character by other workers.

TABLE 12.—*Spleen size and blood smears.*

Positive smears.	Spleen size.						
	Not palpable.	P. D. I.	1	2	3	4	Total.
Examined	79	14	43	27	14	6	104
Positive	5	9	18	14	7	5	53
Do per cent	6.3	64.3	41.2	52.0	50.0	83.3	50.9

ANOPHELES RECONNAISSANCE

TECHNIC

The collection and handling of mosquito larvæ offered a considerable problem for solution. The dippers used were 4 inches deep and had a spout on one side guarded with fine-mesh screening so that excess water could be poured out without loss of larvæ. These dippers had a ferrule into which was inserted a 3-foot walking cane as a handle. These dippers proved to be highly satisfactory for the collection of Philippine anophelines. Collections were made by forcing the dipper down into the water near collections of bamboo roots, grass, etc., and allowing the water to run into the dipper from among the roots or grass. It was frequently found that larvæ were hidden so far up among the roots of bamboo that several dips in the same place were necessary to dislodge them.

Larvæ so collected were removed with a medicine dropper, the tip of which had been enlarged, and placed in a half pint fruit jar half filled with water from the place in which the larvæ were collected. These jars were sealed by the use of a jar rubber and cap held down by the ordinary device used on fruit jars. The number and exact location were noted on a label pasted on the jar and an elaborated descriptive note entered in the collection book.

The collection jars were placed in special holding boxes and transported until the end of the day. At each prolonged stop the jars were opened for the ingress of fresh air. At night the collections were carefully inspected; all fourth-stage larvæ were removed and placed in hot water momentarily to kill and straighten them out. They were then preserved in formalin-filled shell vials, numbered and brought to Manila for identification. All larvæ smaller than fourth stage were fed a mixture of two parts of powdered litmus milk and one part of powdered dried blood serum until they were large enough to remove. Some specimens were allowed to breed out and the adult mosquitoes identified. We have transported live larvæ for periods up to twenty-one days. It was found that the larvæ breed out much more slowly than in nature. By aërating the water at frequent intervals and subjecting the containers to as little agitation as possible, it was found that the loss of larvæ from death was very small.

CLASSIFICATION

There has been considerable confusion regarding the specific identity of Philippine *Anopheles* but the history of this question cannot be considered in this report. The more recent papers bearing on this subject are by Manalang,(40) Baisas,(41) and King.(42, 43, 44) The three articles by King are particularly important in this regard. Based on a study of the above sources and others, and in consultation with W. V. King, we have used the following classification of Philippine *Anopheles:*

1. *Anopheles aitkeni* James, 1913.
2. *Anopheles barbirostris* Van der Wulp, 1884.
3. *Anopheles filipinæ* Manalang, 1929.
4. *Anopheles fuliginosus* Giles, 1900.
5. *Anopheles gigas* var. *formosus* Ludlow, 1909.
6. *Anopheles hyrcanus* var. *nigerrimus* Giles, 1900.
7. *Anopheles hyrcanus* var. *sinensis* Wiedemann, 1928.
8. *Anopheles insulaeflorum* Swellengrebel and Swellengrebel de Graaf, 1920 (*A. aitkeni* var.).
9. *Anopheles karwari* James, 1903.
10. *Anopheles kochi* Donitz, 1901.
11. *Anopheles leucosphyrus* Donitz, 1901.
12. *Anopheles lindesayi* var. *benguetensis* King, 1931.
13. *Anopheles litoralis* King, 1932. (Salt-water *ludlowi.*)
14. *Anopheles ludlowi* Theobald, 1903. (Fresh-water *ludlowi.* In the past *litoralis* has also been included as *A. ludlowi.*)
15. *Anopheles maculatus* Theobald, 1901.
16. *Anopheles mangyanus* Banks, 1906. (Probably identified in previous collections as *A. minimus*, possibly *A. filipinæ* and perhaps *A. funestus* of Manalang.)
17. *Anopheles minimus* Theobald, 1901. (*A. febrifer* Banks, 1914, included chiefly *A. mangyanus*, probably, but also included *A. minimus* and *A. filipinæ*. See King.(44) Manalang's *A. funestus* is chiefly *A. minimus* but may include sometimes *A. mangyanus.* It may be necessary to call the Philippine *minimus*, *Anopheles minimus* var. *flavirostris* Ludlow, 1914.)
18. *Anopheles parangensis* Ludlow, 1914.
19. *Anopheles philippinensis* Ludlow, 1902.

20. *Anopheles pseudobarbirostris* Ludlow, 1902.
21. *Anopheles subpictus* var. *indefinitus* Ludlow, 1904. ("A. rossi.")
22. *Anopheles tesselatus* Theobald, 1901.
23. *Anopheles umbrosus* Theobald, 1903.
24. *Anopheles vagus* var. *limosus* King, 1932.

It must be borne in mind that this list is not a final one by any means. Most of our collections have lot numbers and have been deposited in the Bureau of Science collection, Manila, or in the collection of W. V. King. Therefore, they will be available for reclassification later if necessary.

In Table 13 the catches of *Anopheles* larvæ are listed by species, and by province and town or barrio. The numbers used correspond to the serial numbers in the above classification list. No. 17 is *A. minimus* and it will be noted that this species was found in nearly all parts of the Archipelago.

In Table 14 are listed the species encountered on this survey and the times each was collected. It will be seen that no specimens of *A. leucosphyrus* or *A. parangensis* were caught. The species most frequently taken were *A. minimus, A. barbirostris,* and *A. maculatus* in the order named.

Certain species were at times taken together in the same breeding place. Some of these associations are shown in Table 15. *Anopheles minimus* with *A. barbirostris,* and *A. minimus* with *A. maculatus* were the commonest associations.

BIOLOGICAL CONSIDERATION

In general, our observations as to the habits of Philippine *Anopheles* are in line with those of Barber et al.,(1) Tiedeman,(9) Mieldazis,(12) Manalang,(46, 47, 48, 49) and King.(42, 43, 44)

BREEDING PLACES

In Table 16 are listed the total number of breeding places from which *Anopheles* larvæ were taken. In Table 17 these collections are further classified.

It will be noted that a fairly wide variety of breeding places were sampled. Streams predominated, then rivers and irrigation ditches in the order named. Four collections were made in wells, *A. minimus* being taken twice in this location. In regard to *A. minimus* breeding in wells, see Russell and Santiago.(50)

In Table 18 are listed the breeding places of *A. minimus* and *A. mangyanus.* Where *A. mangyanus* was found it was usually taken in association with *A. minimus* but the reverse is seldom true. Not until the reconnaissance was almost over was the work of King (44) available.

We had, of course, noticed some variation in the *minimus* larvæ but until King (44) made the significance of this variation clear, we had followed the usual plan of calling these variants *A. minimus*. When it became apparent that *A. mangyanus* is entitled to specific status, King began a reparation of our *minimus* collection into the two groups, *mangyanus* and *minimus*. In Table 19 there is a list of breeding places where *A. mangyanus* was found. In Table 20 is a list showing the reverse, *A. mangyanus* but not *A. minimus*.

It is clear from Tables 13 to 20 that one should not be too dogmatic in describing the breeding places of the *A. minimus* group. In any part of the Archipelago, clear, shady streams are most apt to harbor larvæ of this group. Frequently, if bamboo is growing along the stream bank the larvæ are most likely to be found breeding among its roots, but *A. minimus* is a versatile creature and does not limit itself to the classical breeding places.

The fact that our collections could not be standardized as to time and area makes it unwise to draw any but general conclusions as to prevalence and breeding habits of the various species. It can be noted, however, that latitude and longitude per se seem to have very little influence within this Archipelago on the prevalence and breeding habits of *Anopheles* larvæ. We could see no essential differences, for example, in the habits of *A. minimus* in Ilocos Norte and Balabac, in Cagayan and Davao, in Bohol and Jolo.

MALARIA TRANSMISSION

No infected mosquitoes were caught during this survey. Epidemiological evidence in the table below points strongly at only *A. barbirostris* and the *minimus* group. They were usually abundant in malarious places and were uncommon or absent in nonmalarial spots.

With very few exceptions these species, and particularly *A. minimus* and *A. mangyanus*, were always associated with malaria. One notable exception was South Ubian Island, in Sulu Province. Here, with a spleen index of 28.2 per cent and a clear-cut history of malaria, we were unable to find *Anopheles* larvæ. There is no fresh water on the island except in water jars, and we failed to find *Anopheles* in these or in salt-water pools. The explanation seemed to be clear, however, for the Moros of this island are constantly going and coming from Tawitawi, some

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species.*

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
ABRA		1932			
Abra River	34	Jan. 6	4, 14, 17, 19, 24	R U C	446
Bangued	31	do	2, 3, 17, 21	S G C B	In town.
Do	33	do	2, 3, 17	S G C	447.3
Palao	32	do	2, 3, 17	R U C	Sinalang River.
ALBAY					
Bogtong	27A	Mar. 1	2, 3, 16, 17, 24	S G C	
Daraga	27	Feb. 29	16, 17	S G C	
Guinobatan	24	do	3, 16, 17	S G C B	
Do	25	do	2, 3, 16, 17	R G B C	
Legaspi	21	do	2, 3, 17	S G B C	
Do	22	do	21	P U C	
Do	23	do	2, 3, 17	S G M	
Mauraro	26	do	2, 16, 17	S G C	
ANTIQUE					
Pandan	8	Feb. 23	2, 17	S G C B	West.
Do	9	do	2, 17	S G C	Near foothills.
Do	10	do	17	S G C B	East.
Do	11	do	2, 20	D U	Shaded.
Do	12	do	2, 17	S G C B	
BATAAN		1930			
Abucay	8	Nov. 5	7	I U M	Town.
Do	9	do	2, 17	R G C	Do.
		1931			
Do	1	Nov. 9	17	S C U	Hacienda Natib.
Do	2	Nov. 10	16, 17	S C U	Do.
Do	3	do	2, 17	S G C	Do.
Do	4	do	7, 17	I U C	Do.

Do	5	do	7, 20	S C U	Do.
Do	6	Nov. 11	16, 17	S G C	Do.
Do	7	do	7, 17	S U C	Do.
Do	8	do	16, 17	S G C B	Do.
Do	9	do	2, 17	S G C B	Do.
Do	10	do	7, 17, 20	S U C	Do.
Do	11	do	16, 17	S G C B	Do.
Do	12	do	16, 17	S G C B	Do.
Do	13	Nov. 13	7, 16, 17	S G C B	Do.
Bagac					Town. No larvæ found.
Bagac to Balanga	8–14B	July, 1931	3, 4, 8, 14, 15, 17, 21	S G C	Trail 9 collections.
Balanga	11	Nov., 1930	4	P C U	Town.
		1931			
Balanga	1	Nov. 21	15, 17	S G C	Hacienda Mataan.
Do	2	do	17	S G C B	Do.
Do	3	do	3, 17	S G C	Do.
Do	4	do	15, 17	S G C B	Do.
Do	5	do	2, 15, 17	I G C	Do.

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
BATAAN—continued		1931			
Balanga	6	Nov. 21	17	S G C	Hacienda Mataan.
Do	7	do	17	S G C	Do.
Do	8	do	17	S G C	Do.
Do	9	Nov. 23	3, 15, 17	S G C	Do.
Do	10	do	3, 15, 17	S G C	Do.
Do	11	do	15, 17	S G C B	Do.
Do	12	do	17	S G C B	Do.
Do	13	Nov. 24	17	S G C	Do.
Do	14	do	17	S G C B	Do.
Do	15	do	17	S G C B	Do.
Do	16	do	3, 17	S G C	Do.
Do	17	do	17	S G C	Do.
Do	18	do	3, 17	S G C	Do.
Do	19	do	17	S G C	Do.
Do	20	do	17	S G C B	Do.
Do	21	Nov. 25	17	S G C B	Do.
Do	22	do	17	S G C B	Do.
Do	23	do	15, 17	S G C	Do.
Do	24	do	17	S G C	Do.
Do	25	do	15, 17	S G C B	Do.
Do	26	Nov. 26	15, 17	I G C	Do.
Do	27	do	3, 17	I G C	Do.
Do	28	do	15, 17	I U C	Do.
Do	29	do	15, 17	R U C	Do.
		1930			
Cupang	12	Nov. 5	2, 17	I U C	Balanga barrio.
Do	13	do	4, 7	P C U	Do.

Corregidor		June, 1931			No *Anopheles* larvæ found. Entire island searched.
		1930			
Dinalupihan	19	Nov. 3	2, 17	R U C B	Layac.
Hermosa	1	Nov. 4	2, 17	S G C	Town.
Do	3	do	7	P C U	Do.
Limay	18	Nov. 6	2, 15, 17	R G C B	Do.
Limay-Bagac	1-7B	July, 1931	2, 3, 8, 16, 17	S G C	Trail 14 collections.
Mariveles		June, 1931	17	S G C	
		1930			
Orani	4	Nov. 4	4, 7	P U M	Town.
Do	20	Nov. 13	21	O P U	Do.
Do	21	do	21	O P U	Do.
Do	22	do	21	O P U	Do.
Do	23	do	21	O P U	Do.
Orion	14	Nov. 5	2, 4	P U C	
Do	15	do	21	P U C	
Do	16	do	2, 4, 17, 19, 21	I U C	

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
BATAAN—continued		1930			
Orion	17	Nov. 6	21	P U C	
Samal	5	Nov. 5	21	I U C	
Do	6	do	21	P U C	
Do	7	do	7	S C U	
		1931			
Sisiman	1	May 22	2, 17	S G C	
BATANGAS					
Batangas	15	Dec. 17	2, 14, 15, 24	R P U	
Cuenca	19	Dec. 18	2, 15	S G C	
Ibaan	12	Dec. 17	14, 15, 17	R C U	
Rosario	13	do	2, 17	S G C	
Do	14	do	15, 17	S G M	
Sabang	11	do	2, 14, 15, 17	S G C	
Tuy	16	do	2, 3, 15, 16, 17	S G C B	
Do	17	do	2, 15, 17	S G C B	
Do	18	do	2, 17	S G C B	
BOHOL		1932			
Agricultural Colony	5	Mar. 29	2, 17	R U C	
Balilihan	1A	do		S G C	No larvæ found.
Calape	3	do	15, 17	S G C B	
Carmen	4	do	2, 17	S G C B	
Loon	2	do	2, 15, 17	S G C	
Tagbilaran	1	do		O R U	Do.
BULACAN		1930			
Baisa	237	Dec. 22	2, 4, 19, 21, 24	P U C	
Malolos					
Marilao					

Tungcong Manga	2	Jan. 6	2, 3, 15, 16	S G C	Matuid Creek.
Do	3	do	4, 19	P G C	
Do	7	Jan. 24	2, 3, 14, 21, 24	R U C	Lower Alat.
Do	8	do	3, 7, 15, 17, 24	S G C	
CAGAYAN		1932			
Aparri		Mar. 13		O U	No larvæ found.
Gattaran	12	do	2, 17	S G C	
Iguig	11	do	17	S G M	
Do		do		R U C	No larvæ in river 3 km south of Iguig.
Tuguegarao	14	do	17	R U C B	
CAMARINES SUR					
Dayandan	34	Mar. 2	2, 7, 17	S P G C	
Naga	34A	do	7, 17	P G	
Pinit, San Jose Road	35	do	3, 17	S G C	Km 31.
Do	36	do	2, 3, 17	S G C	
Do	37	do	2, 3, 16, 17	S G C	
Pasacao	38	do	2, 3, 7, 15, 16, 17	S G C B	

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.
D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.
G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
CAPIZ		**1932**			
Buntog	16A	Apr. 3		R M U	No larvæ found.
Capiz	15	do	21	O P U	
Do	16	do	7, 19, 21	P U C	
New Washington	13	Feb. 24	13, 21, 23	O P U	
Do	14	do	7, 19, 21	P U	
CAVITE					
Indang	2	Mar. 22	15, 17	S G C	
Do	2A	do	2, 15, 17	S G C	
Naic	3	do	17	S G M	
Ternate	1	do	17	W U C	
CEBU		**1930**			
Cebu	238	Nov. 29	13, 21	O P U	
Labangon	239	do	14, 17	S G C	
		1932			
Mambaling	1	Jan. 17	2, 17	S G C B	
Mandawe	2	do	13	O P U	Km 7 from Cebu.
Do	3	do	13	O P U	Do.
Tabunoc	3A	do	14, 15, 17	S G C	
Toledo	6	Mar. 30	2, 17	S G C	Km 3.5 from Toledo toward Cebu.
DAVAO		**1930**			
Davao	4	Jan. 30	2, 20, 22	S G M	
Matina	6	do	17	S G M	
Mintol	5	do	17	I M U	
Do	10	Jan. 31	17, 20, 22	I M U	
Do	11	do	2, 17, 22	S G M	
Pakiputan	8	do	2, 23	R U M	
Do	8A	do	22	P G	

Do	9	do	2, 20, 24	P G	
Talomo	7	Jan. 30	17	S G C	
ILOCOS NORTE		1932			
Bangui	1	Jan. 3	2, 3, 7, 15, 17, 22	I U C	K 603
Do	2	do	2, 4, 7, 19, 24	I U C	K 601
Do	3	do	2, 7	I U C	599
Do	4	do	2, 17	I U C	597
S. Bautista	5	do	2, 17	S G C	595-596
Km 591	6	do	2, 4, 24	R G C	591
Km 588	7	do	2, 3, 4, 7, 19	I G C	588
Baruyan River	8	do	2, 15, 17	R U C	
Asido	9	do	2, 17	S G C	575+
Kms 566-65	10	do	2, 3, 7, 17	S G C	
San Mateo	11	Jan. 4	2, 17	R U C	
Laoag	12	do	2, 14, 17, 19	R G C B	Laoag River.
Bacarra	13	do	17	I U C	
Laoag	14	do	17	S G C	536
Do	15	do	17	I U C	535

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

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I, irrigation ditch, flowing.
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O, ocean salt water.
B, bamboo.

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U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
ILOCOS NORTE—continued		1932			
Badoc	16	Jan. 4	2, 3, 4, 17	S G C	Town.
Do	17	do	2, 4, 17	S G M	495
Paoay	19	do	2, 7, 20	R G M	508
Batac	21	do	2, 17	S G C B	516
Do	22	do	17	S G C	518
Do	22A	do	2, 3, 17	S G C B	526.67
ILOCOS SUR					
Bantay	27	Jan. 5		S G C B	442. None found.
Do	28	do		S G M B	445. None found.
Do	29	do	2, 17, 20	S G M	447.29
Cabugao	23	do	2, 3, 17	S G C B	475.8
Do	24	do	4, 14, 21	R U C	
Do	25	do	17	S G C B	East.
Suyo	35	Jan. 6	2, 17	R U C	
Do	36	do	2, 3, 15	P C U	
Do	37	do	17	S G C	
Do	38	do	2, 17	S G C B	
Vigan	26	Jan. 5	2, 3, 17, 19, 21	S U M	Southeast of Vigan.
Do	30	do	2, 17, 21	S U M	Half a km north.
ILOILO					
Iloilo	21	Apr. 4	12	O P U	Fishpond.
Leon	19	do		S G M B	Foothill. None found.
Do	19A	do	14, 24	R G C	River East.
Passi	17	do	2	R U C	Main river.
Do	18	do	2, 21	S G C	Branch of river.
Jaro	20	do	2	R U C	River.

ISABELA					
Echague	10	Mar. 12	2, 7, 17	S G C B	
Ilagan		Mar. 14			None found in river. All small streams dry.
LAGUNA		1931			
Calauan	10B	Dec. 16	2, 17	S G C	Macalauan stream.
Do	10C	do	2, 15, 17, 21, 24	S G C	Mabacan branch.
Do	10D	do	2, 4, 7, 17, 21, 24	S G C	Ilat stream.
Do	10E	do	2, 4, 5, 7, 19, 20, 21	P C G	Tangke spring.
Mabitac	7	Dec. 15	2, 9, 17	S G C B	One km north.
Magdalena	10	Dec. 16	2, 17	S G C B	East.
Do	10A	do	2, 16, 17	S G C B	Do.
Santa Maria	8	Dec. 15	2	S G C	West.
Do	8A	Dec. 26	2, 10, 17	S G C B	Do.
Do	8B	do	2, 10, 17	S G C B	South.
Do	8C	do	2, 4, 17	S G C B	Do.
Do	8D	do	24	P U	East.
Siniloan	5	Dec. 15	2	S G C	
Do	6	do	2, 6, 7, 20	D U	

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
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D, ditch, still.
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TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
LAGUNA—continued		1931			
Dayap to Pila	5	Dec. 30	2, 16, 17	R G C B	Bridge, 81.86
Do	6	do	2, 17	P U	Bridge, 83.80
Do	7	do	2, 3, 17	P U B	Bridge, 83.84
Do	8	do	2, 17	I U C	Bridge, 83.84
Do	9	do	2, 17	I U C	Bridge, 83.80
Do	10	do	17	S G M	Between 83.84 and 83.93
Do	11	do	2, 17	S G M	Bridge 83.93
Do	12	do	2	R G M B	Bridge 85.62
		1932			
Pila to Santa Cruz	13	Jan. 6	2, 17	S G M	Bridge 87.29
Do	13B	do	17	P U C	Bridge 87.29
Do	14	do	2, 6, 17	I M U	Bridge 87.76
Do	15	do	2, 17	S G C	Bridge 90+
Do	16	do	2, 10, 17, 20	I C U	Between 90+ and 90.33
Do	17	do	2, 6, 17	I C U	Bridge 90.33
Do	18	do	2, 6, 7	I C U	Bridge 93.35
Do	19	do	6	P U	Bridge 95.96
Do	20	do	6, 22	I M U	Bridge 95.96
Do	21	do	6, 17, 22, 24	I M U	Bridge 96.22
Do	22	do	2, 4, 6, 7, 17, 24	R M G B	Bridge 96.90
Santa Cruz to Magdalena	23	Jan. 13	2, 17	R G M	Bridge 98.89
Do	24	do	2, 3, 17	S G C	Bridge 100
Do	25	do	2, 17	S G C B	Bridge 100.49
Do	26	do	2, 17	S G C	Km 120
Do	27	do	2, 17	S G C	Bridge 117.43
Do	28	do	17	S G C	Bridge 117.21
Calauan to San Pablo	29	Jan. 20	2, 3, 15, 17	R G C	Road bridge 85.2
Do	30	do	2, 15, 17	S G C	Bridge 86.1

Do	31	do	15, 17	R G C	Bridge 89.73
Do	32	do	2, 17	R G C	Malinao River.
San Pablo to Rizal	33	Jan. 27	2, 15, 17	S G C	Between Km 91 and 92
Do	34	do	15, 17	S G C	Bridge 93.67
Do	35	do	15, 17	S G C	Bridge 95.02
Do	36	do	17	S G C	Bridge 95.08
Do	37	do	2, 24	I U M	Bridge 98.14
Rizal to Nagcarlan	38	Feb. 3	10, 15, 17	S G C	Km 99
Do	39	do	15, 17	S G C	Bridge 100.44
Do	39A	do	2, 20	P U	
Do	40	do	15, 17	I U C	Bridge 102.59
Do	41	do	2, 3, 7, 17	I G C	Bridge 102.95
Nagcarlan to Lilio	42	Feb. 10	17	S G C	103.43
Do	43	do	17	R C G	San Diego River.
Do	44	do	2, 17	S G C B	106.21
Do	45	do	17	S G C B	106+
Do	46	do	17	S G C B	106.44
Do	47	do	2, 17	S G C B	107.42

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Anopheles—
1. ***aitkeni.***
2. ***barbirostris.***
3. ***filipinæ.***
4. ***fuliginosus.***
5. ***gigas* var. *formosus.***
6. ***hyrcanus* var. *nigerrimus.***
7. ***hyrcanus* var. *sinensis.***
8. ***insulaeflorum.***

Anopheles—
9. ***karwari.***
10. ***kochi.***
11. ***leucosphyrus.***
12. ***lindesayi* var. *benguetensis.***
13. ***litoralis.***
14. ***ludlowi* (fresh-water).**
15. ***maculatus.***
16. ***mangyanus.***

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
LAGUNA—continued		1932			
Nagcarlan to Lilio	48	Feb. 10	2, 17	S G C	107.68
Lilio to Magdalena	49	Feb. 17	2, 15, 17	S G C B	108.21
Do	50	do	15, 17, 20	S G C B	109.33
Do	51	do	17	I U	110.87
Do	52	do	2, 17	I U	110.87
Do	53	do	17	I U	111.20
Do	54	do	2, 17	S U	112+
Do	55	do	17	S G C	112.95
Do	56	do	2, 15, 17	I U	Km 114-115
Calauan to Bay	57	Feb. 24	2, 7, 17, 24	S U M	Km 75.1
Do	58	do	2, 4, 6, 7, 17, 24	I C U	Km 73
Do	59	do	2, 3, 7, 17, 22	S U C	Km 74.4
Do	60	do	2, 7, 17, 20	I G C	Km 72
Do	61	do	2, 17	R U C	Km 72.8
Do	62	do	2, 17	R G C	Km 71.17
Do	63	do	2, 17	I U C	Km 71.17
Bay to Los Baños	64	Mar. 9	17	I G C	Km 69
Do	65	do	2, 4, 20	R M U	Km 71.15
Do	66	do	2, 4, 20, 21	I U M	Km 70.92
Do	67	do	2, 17	R G C	Km 70.57
Do	68	do	2, 17	S G C	Km 70.5
Do	69	do	17, 24	S G C	Km 67
Los Baños to Calamba	70	do	17, 24	S G M B	Km 65.38
Do	71	do	3	I U C	Km 65.07
Do	72	do	2, 24	P U	Km 65.07
Do	73	do	2, 3	P G	Km 63.54
Do	74	do	17	I G C	Km 63.23
Do	75	do	24	P G	Km 62.85
Do	76	do	24	P U	Km 62.85

Do	77	do	3, 17	S G C	Km 59.89
Do	78	do	21	L U C	Pansol beach.
Do	79	do	3	L U C	Do.
Do	80	do	21, 24	P U M	Pansol Railroad station.
Do	81	do	3, 17	R U C	Km 58.80
Do	82	do	4, 6	I M U	55
Calamba to Cabuyao	83	Mar. 10	21	R U C	West of Calamba School.
Do	84	do	4, 21	R U C	54.31
Do	85	do	24	I M U	52.53
Do	86	do	17	I M U	49.90
Do	87	do	2, 17	S G C B	47.95
Do	88	do	2, 17, 21	R G C B	47.06
Do	89	do	2, 3, 17	R G M	45.39
Do	90	do	24	F C U	45.06
Cabuyao to Santa Rosa	91	do	4, 6, 17, 21	I U M	45.06
Do	92	do	17	S G C	43.75
Do	93	do	17	I G M	43.38
Do	94	do	2, 4, 17	I G M	42.90

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

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TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
LAGUNA—continued		1932			
Cabuyao to Santa Rosa	95	Mar. 10	2, 6, 17, 24	I G M	42.41
Do	96	do	2, 3, 15, 17, 24	R G C	42.20
Santa Rosa to Biñan	97	Mar. 12	6	I U C	40.20
Do	98	do	17	S M G B	39.74
Do	99	do	6, 17, 24	S M G	39.25
Do	100	do	17	S M G	39.18
Do	101	do	2, 4, 17, 21	R M G	36.55
Biñan to San Pedro	102	do	2, 17	R U C	Near public market.
Do	103	do	2, 17, 21	R G C B	31.44
Do	104	do	2, 3, 17	S G C B	31.2
Sambat to Majayjay	105	Mar. 16	2	I G C	113.79
Do	106	do	2, 17	I U C	114.24
Do	107	do	2, 17	I G C	114.24
Do	108	do	17	S G M	115.15
Do	109	do	2, 10, 17	I G C	Between 116–117
Do	110	do	17	I U C	Do.
Do	111	do	17	I G C	118.75
Do	112	do	2, 17	I U C	118.75
Do	113	do	17	S G M	118.75
Do	114	do	2, 17	S G M	119.85
Do	115	do	2, 3, 17	S G C	120.22
Do	116	do	2, 3, 17	S G C	120.50
Do	117	do	15, 17	I G C	120.50
Pagsanjan to Cavinti	118	do	17, 24	R G C	101.42 clear, shady, grassy.
Do	119	do	2	R G C	Near market, clear shady, grassy.
Do	120	do	15, 17	S G C	Between 104–105 clear, shady, shallow.
Do	121	do	2, 19, 20, 24	S G U	Between 107–108 clear, shallow, open.
Do	122	do	2, 3, 17	S G M B	Between 108–109 muddy bamboo.
Do	123	do	2	P G M	Near 110, muddy, vegetated, shady debris.

Do	124	do	2, 3, 17, 24	S M G	110+ muddy, shady, roots grasses.
Do	125	do	2	S M G	110+ muddy, shallow, shady.
Do	126	do	2, 17	R G M	111 muddy debris.
Linga to Pinagbayanan	127	do	21	L U C	Linga Beach, algæ, grasses.
Do	128	do	17	R G M B	Pinagbayanan River, lilies, muddy, bamboo.
San Pablo and Alaminos	129	do	2, 15, 17	S G C	87.74 clear, shady.
Do	130	do	2, 15, 17	S G C	86.14 clear, shady.
Do	131	do	15, 17	S G C	Southeast of Alaminos School.
San Pablo and Tiaong	132	do	15, 17	S G C	91.64
Do	133	do	17	S G C	92.06
Do	134	do	17	S G C	93.87
Do	135	do	2, 15, 17	S G C	96.22
Do	136	do	2, 3, 17, 24	S G C	98.73
Do	137	do	24	P U M	101+
Do	138	do	17	R G C	101+
Santa Cruz Beach	139	do	4, 7, 19, 21	L U C	Santa Cruz Beach.
Calamba to Santo Tomas	140	do	2	S G C B	62.84
Do	141	do	15, 17, 24	S G C	65.41

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
LANAO		1930			
Kolambugan	1	Dec. 23–26	2, 20, 23, 24	Swamp U	Salt-water swamp.
Do	2	do	15	S G C	Clear, moderately shaded.
Do	3	do	2, 7, 23, 24	R U C	Not shaded.
LA UNION		1932			
Bauang	39	Jan. 7	2, 17	S G C B	Shady bamboo.
Burgos	40	do	2, 3, 15, 17	R U C	309
Saitan	41	do	2, 3, 15, 17	S G C B	246
LEYTE					
Carigara	18	Feb. 26	2, 17	R G C	Rapid, clear.
Talibong (Biliran Island)	19	do	15, 17, 24	S G C	
MINDORO					
Camboag (San Jose)	6	Feb. 22	2, 3, 7, 17	S G C	Deep, moderately shaded.
Do	7	do	2, 17	S G C	
Caminawit	1	do	21	P C	
Pandurucan	2	do	13	O P U	
Do	3	do	21, 24	P G C	
San Jose	4	do	17	S G M	
Do	5	do	2, 17	S G M	
MANILA		1930			
Malacañang	18–19	Feb. 6	2, 6, 7, 24	P C U	
		1932			
Malate	1	Mar. 19		O P U	No larvæ found.
Maypajo	2	do	13	O P U	
MASBATE					
Masbate	15	Feb. 25	15	I G C	
Do	17	do	15, 16, 17	S G C	
Tagba	16	do	2, 3, 15, 17	S G C	

MISAMIS					
Cagayan	1	Nov. 30	3, 17, 19	S G C	
Gingoog	2	Dec. 3-9	3, 4, 15, 17, 20	R G C B	
Gusa	3	Nov. 30	17	S G C	
MOUNTAIN					
Baguio	104	May 2	5, 12, 15	I U C	Pack and Kisad Roads.
Do	105	May 4	7, 15	F U C	K 276
Do	105A	do	4, 15	S G C	K 277
Do	106	May 5	5, 12, 15	I U C	Bureau of Forestry.
Do	107	do	5, 12, 15	F U C	Pack Road.
Do	108	May 8	5, 12	S G C	Camp John Hay.
Do	95	Apr. 29	5, 12	S G C	Do.
Do	96	May 30	7, 5, 12	S G C	Do.
Do	94	May 28	7, 15	I U C	Trinidad Valley.
Cervantes		Jan., 1931	15, 17	S G C	
Kiangan		Dec., 1931		S U C	No larvæ found.
Loo		do		R U C	Do.
Tawan		do		S G C	Do.

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
NUEVA ECIJA		1932			
Bongabon	2	Mar. 10	2, 3, 4, 17	S G C B	
Cabiao	13	Mar. 15	2, 17, 20	R G C B	
Cabu	1	Mar. 10	2, 17	S G M	
Puncan	4	do	2, 17	S G C	
San Jose	3	do	2, 17	S G C B	
NUEVA VIZCAYA					
Bagabag	7	Mar. 11	2, 3, 17	S U M	
Bambang	6	do	2, 3, 17	S U M	
Bayombong	8	do	2, 14, 17	R U C	
Rosario (Km post 298)	9	Mar. 12	2, 17	S U C B	
Santa Fe	5	Mar. 11	2, 15, 17, 24	S G C	
OCCIDENTAL NEGROS					
Bacolod	9	Mar. 31	2, 7, 17, 21	S G C B	K 3-5 north on road to Talisay.
Do	10	do	2, 17	S G C B	K 2-5 Talisay.
Isabela	11	Apr. 1	2, 17	S G C B	Southeast.
Murcia	12	Apr. 2	7, 24	W M U	K 2 north.
Do	13	do	24	S G M	50 yd. north.
Do	14	do	2, 17, 21, 24	R G C	Sumag River.
San Carlos	7	Mar. 30	15, 17	S G C B	K 2 southwest.
Do	8	do	21, 24	S U M	K 1-5 northwest.
ORIENTAL NEGROS					
Dumaguete	29	Feb. 12	15, 17	S G C B	Km 3 south.
Do	30	do	17, 20	I G C	Km 5 south.
PALAWAN					
Balabac	5	Apr. 3	2, 17	S G C	
Baja Point	6	Apr. 5	2, 17	S G C	Malabuniga River.
Coron		Mar. 28			Streams dry; none found.

Culion	1	do	2, 17	S G C	1 km east of hospital.
Cuyo		Mar. 29			None found.
Iwahig	2	Mar. 30	17, 21	S U C	Balsabang River.
Do	3	Mar. 31	17	S G C	Lakondola River.
Do	4	Apr. 1	7, 17	S G C	Kasuyan River.
Puerto Princesa		Mar. 30			None found.
PAMPANGA		1930			
Del Carmen		Jan. 6	2, 7, 17, 19	R U C B	
Do		Jan. 23	2, 17	R U C	
Do		Mar. 18	2, 17	R U C	
Do		Feb. 6	2, 17	R U C B	
Floridablanca		Feb. 19	14, 17, 21, 24	R G C	
Porac	34	do	4, 14, 17, 21	R G C B	
PANGASINAN		1932			
Alaminos	45	Jan. 8	2, 17, 21	S G B	1.5 km southeast.
Infanta	47	do	19	P	Town.
Lingayen	44	do	21	P O	Do.

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.
D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.
G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
PANGASINAN—continued		1932			
Mabini	46	Jan. 8	17	R G B	0.3 km east.
Malasiqui	43	Jan. 7	17	S G M	0.1 km northeast.
Urdaneta	42	do	2, 17, 20	R P M	202.5
RIZAL		1930			
Antipolo-Las Piñas	47	Mar. 5	14	P U C	
		1931			
Las Piñas	225	Nov. 13	13, 21	O P U	
		1932			
Navotas	4	Mar. 19			None found.
Parañaque		do	13	O P U	
		1930			
Pasay	26	Feb. 13	13, 21	O P U	
San Francisco del Monte	1	Jan. 4	2, 17	S G C B	
San Juan del Monte	5	Feb. 7	2, 6, 7	R M U	
SAMAR		1932			
Allen	20	Feb. 27	2, 15	R P U C	
Do	20A	do	2, 15 16, 17	R U C	
SORSOGON					
Bulusan	28	Mar. 1	15, 17	S G C	
Putiao	33	do	2, 3, 15, 16, 17	S G M	
Rizal Barrio	31	do	2, 3, 15, 16, 17	I U C	
Do	32	do	2, 17	W S C	
Sorsogon	29	do	2, 3, 15, 16, 17	S G C	
Do	30	do	2, 15, 16, 21, 24	P U C	

SULU					
Astorias, Jolo	23	Feb. 5	2, 17	S G C	
Bato-bato		do	17	S G C	
Bongau		do	17	S G C	
Jolo, Jolo	21	do	17	S G M	Camp Romandies.
Do	22	do	21	O P U	Camp Listt.
Do	24	uo	17	S U C	
Do	25	do	17, 20, 21	S U C	
Do	25A	do	17	S G C	
Lapac Island	27B	Feb 7			No larvæ found.
Lugus Island	28	do	21	L U C	
Do	28A	do	21	L U C	
Do	28B	do	21	W G C	
Maimbong, Jolo	18A	Feb. 5	17	S G C	
Manubul Island	27C	Feb. 7			No fresh water on island. No larvæ found.
Pantao, Jolo	20A	Feb. 5	17	S G C	
Siasi Island	26	do	17, 20, 21, 24	S G C	
Do	27	Feb. 6	17, 20	S G C	

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water).
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

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U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
SULU—continued		1932			
South Ubian	27A	Feb. 6			Thoroughly searched. No larvæ found. *Aëdes* on water jars. No fresh water on island.
Tabo-tati, Jolo	18	Feb. 5	17	S G C	
Tandu-Bato, Jolo	20	do	17	S G C	
TAYABAS		1931			
Atimonan	12	Nov. 27	2, 9, 15, 16, 17	S G C	K 169+
Do	13	do	16, 17	S G C	K 169
Do	14	do	15, 16, 17	S G C	K 168
Atimonan–Pagbilao Road	6	do	15	S G C	K 176
Do	7	do	15	S G C	K 174
Do	8	do	2, 15, 17, 19, 24	S G C P	K 173+
Do	9	do	15, 17	S G C	K 171
Do	10	do	15, 16	S G C	K 171
Do	11	do	2, 3, 15, 17	S G C	K 170
Do	15	Feb. 28	15, 16, 17	S G C	K 162
Do	16	do	2, 16, 17	S G M	K 161
Do	17	do	2, 15, 16, 17, 20	S G C B	K 160
Do	18	do	2, 3, 17	S G M	K 159
Do	19	do	8, 15, 16, 17	S G C B	K 157
Do	20	do	15	S G C	K 155
Do	21	do	2, 8, 15, 16, 17	R M U	K 153
Candelaria	48	Dec. 3	2, 15, 17	S G C B	K 108+
Gumaca	1	Nov. 29	15, 17	S C U	K 203
Do	2	do	15, 17	S C U	K 203
Gumaca to Atimonan	3	do	15	S C U	K 200
Do	4	do	21	O P U	K 192+
Do	5	do	15, 24	S C U	K 176

Lucban to Sampaloc	27	Nov. 28	3, 17	R U C	K 163
Lucban to Tayabas	28	do		S G C	K 154+. No larvæ found.
Do	29	do		S G C	K 160. No larvæ found.
Lucena to Pagbilao Road	35	Nov. 30	7	S U M	K 138
Do	38	do	2, 10, 17	S U M	K 142+
Do	39	do	2, 16, 17	S G M B	K 144
Do	40	do	2	S U M	K 144+
Mauban to Sampaloc	30	Nov. 28	15, 17	S G C	K 182
Do	31	do	17	S G C	K 181
Do	32	do	16, 17	R G C	K 180
Pagbilao to Tayabas	25	do	2, 17	R G C B	K 142
Sariaya to Candelaria	47	Dec. 2	2, 17	S G C B	K 114
Tayabas to Lucban	26	Nov. 28	16, 17	S G C	K 150+
Tiaong to San Pablo	50	Dec. 2	2, 17	S G M	K 91+
ZAMBALES		1932			
Candelaria	48	Jan. 8	2, 3, 17	S G	2 km south.

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water)
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ.[a]	Breeding places.[a]	Remarks.
ZAMBALES—continued		1931			
Castillejos	17A	July 30	14, 16, 17	S G B C	Aninguay River.
Do	17B	do	2, 17, 24	S G B C	Do.
		1932			
Iba	49	Jan. 8	2, 17	S G M	Town.
		1931			
Olongapo	14	July 29	1, 2, 16, 17	R G C	Batoc River.
Do	14B	do	2	F U	Near Batoc River.
Olongapo-Dinalupihan	13F	Aug. 1	16, 17	S G C	Beyond Santa Rita.
Do	13G	do	2, 15, 16, 17	S G C	Mountain stream.
Do	13H	do	16, 17	S G C	Do.
Do	13I	do	17	S G C	Do.
Do	13K	do	17	S G C	Do.
San Antonio	20	July 30	4	I M C	North.
Do	21A	do	4, 14, 17, 19	S C G	Calpalman.
		1932			
San Marcelino	50	Jan. 9	4, 17	S G C	Foothills north.
		1931			
San Narciso	44B	July 30	7, 21	S C U	Kayaran stream.
Santa Rita	13A	July 29	2, 16, 19, 21	S C G	Near cabaret.
Do	13B	do	14, 15, 16, 17, 20	S C G	Near school.
Subic area	2	July 28	14, 15	S C U	Southwest.
Do	3	do	14, 15	S C U	Do.
Do	3A	do	14, 15	S C G	Do.
Do	4B	do	14, 15, 17	S C G	Do.
Do	4C	do	4, 14, 19, 21	S C G	Do.
Do	5B	do	2	S C G	Do.
Do	9A	do	14, 15, 16, 17	S C U	Do.

Do	9C	do	16, 17	S C U	Do.
Do	10	do	15, 17	R C G	Do.
Do	12A	July 29	1, 16, 17	S C G	Northeast.
Do	12B	do	16, 17	S C G	Do.
Do	15A	July 30	1, 2, 14, 15, 16, 17	S C G	Do.
ZAMBOANGA					
Kabasalan	1B	Sept. 27	2	S U C	
Do	1C	do	8	S U C	
Do	1D	do	2, 8	S U C	
Do	101	do	1, 8, 17	S G C	
Do	102	do	8, 17	S G C	
Do	103	do	2, 17	S U C	
Do	104	do	2	S G C	
Do	105	Sept. 29	2, 17, 22	I C U	
Do	106	do	17, 22	I C U	
Do	107	Sept. 28	1, 8	S G C	

[a] The species of the mosquito larvæ collected are indicated by numbers and the types of breeding places by letters, as follows:

Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water)
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 13.—*Anopheles larvæ taken during the reconnaissance, listed by province, town or barrio, and species*—Continued.

Locality.	Lot No.	Date.	Larvæ. [a]	Breeding places. [a]	Remarks.
ZAMBOANGA—continued		1931			
Kabasalan	108	Sept. 28	2	S G C	
Do	109	do	22	I U C	
Do	110	do	17	I U C	
Do	111	Sept. 29	2	I U C	
Do	112	Sept. 30	17	S G C	
Do	112A	do	3, 17	S G C	
Do	113	Oct. 1	17	S G C	
Do	114	Oct. 2	17	S G C	
Do	114A	do	2, 17	S G C	
Do	115	do	2, 8, 17, 20	S G C	
Do	116	do	17	S G C	
Do	117	do	2, 8, 17, 24	S C U	
Do	118	Oct. 3	2, 8, 17	S C U	
Do	118A	do	2, 8	S C U	
Do	119	do	2, 6, 20	I U C	
Do	120	do	2, 15, 17	I U C	
Do	121	Oct. 5	2, 17, 22	I U C	
Do	121	do	2, 7, 15, 22	S G C	
Do	122	do	8	S G C	
Do	123	Oct. 6	20, 22	P U	
Do	124	do	2, 15, 24	P U	
Do	125	Oct. 6	2	R U C	
Do	126	do	17, 19, 22	S G C	
Do	127	do	17	S G C	

		1932			
Limajon	12	Feb. 2	17	S G C	
Mercedes	15	Feb. 3	2, 17	S G C	
Tulungatung	16	do	17	S G C	100 yds. from town.
Do	17	do	2	S G C	0.5 km from town.
Tumaga	13	Feb. 2	17	S G C B	
Zamboanga	14	Feb. 3	2, 17, 21	I C U	

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Anopheles—
1. *aitkeni.*
2. *barbirostris.*
3. *filipinæ.*
4. *fuliginosus.*
5. *gigas* var. *formosus.*
6. *hyrcanus* var. *nigerrimus.*
7. *hyrcanus* var. *sinensis.*
8. *insulaeflorum.*

Anopheles—
9. *karwari.*
10. *kochi.*
11. *leucosphyrus.*
12. *lindesayi* var. *benguetensis.*
13. *litoralis.*
14. *ludlowi* (fresh-water)
15. *maculatus.*
16. *mangyanus.*

Anopheles—
17. *minimus* (*flavirostris*).
18. *parangensis.*
19. *philippinensis.*
20. *pseudobarbirostris.*
21. *subpictus* var. *indefinitus.*
22. *tesselatus.*
23. *umbrosus.*
24. *vagus* var. *limosus.*

BREEDING PLACES

S, stream.
R, river.
P, pool.
L, lake.
F, rice field.

D, ditch, still.
I, irrigation ditch, flowing.
W, well.
O, ocean salt water.
B, bamboo.

G, shaded.
U, unshaded.
C, clear.
M, muddy.

TABLE 14.—*Species of Anopheles encountered in survey and number of times found.*

Serial No.	Species.	Times collected.
1	*Anopheles aitkeni*	5
2	*Anopheles barbirostris*	254
3	*Anopheles filipinæ*	68
4	*Anopheles fuliginosus*	35
5	*Anopheles gigas* var. *formosus*	7
6	*Anopheles hyrcanus* var. *nigerrimus*	17
7	*Anopheles hyrcanus* var. *sinensis*	48
8	*Anopheles insulaeflorum*	14
9	*Anopheles karwari*	2
10	*Anopheles kochi*	6
11	*Anopheles leucosphyrus*	0
12	*Anopheles lindesayi* var. *benguetensis*	6
13	*Anopheles litoralis*	10
14	*Anopheles ludlowi*	25
15	*Anopheles maculatus*	109
16	*Anopheles mangyanus*	50
17	*Anopheles minimus*	378
18	*Anopheles parangensis*	0
19	*Anopheles philippinensis*	21
20	*Anopheles pseudobarbirostris*	30
21	*Anopheles subpictus* var. *indefinitus*	61
22	*Anopheles tesselatus*	15
23	*Anopheles umbrosus*	4
24	*Anopheles vagus* var. *limosus*	53

TABLE 15.—*Association of two or more species of Anopheles in the same breeding place.*

Serial Nos.	Species in association.	Times found together.
2 and 17	*Anopheles barbirostris* and *A. minimus*	178
15 and 17	*Anopheles maculatus* and *A. minimus*	101
16 and 17	*Anopheles mangyanus* and *A. minimus*	25
2, 15, and 17	*Anopheles barbirostris, A. maculatus,* and *A. minimus*	36
3 and 17	*Anopheles filipinæ* and *A. minimus*	61
3, 15, and 17	*Anopheles filipinae, A. maculatus,* and *A. minimus*	17
2, 3, and 17	*Anopheles barbirostris, A. filipinæ,* and *A. minimus*	44
17 and 24	*Anopheles minimus* and *A. vagus* var. *limosus*	21
2, 17, and 24	*Anopheles barbirostris, A. minimus* and *A. vagus*	16
2, 17, and 21	*Anopheles barbirostris, A. minimus,* and *A. subpictus*	13

seven miles west, where they secure their drinking water. Whole families go to this island sometimes to spend one or more days. Tawitawi is known to be highly malarious. Furthermore, these people are fishermen and go to the neighboring islands to spend weeks at a time. Therefore, they have had many opportunities to become infected in places where *A. minimus* is breeding.

The only other notable exception to the rule of an association between malaria and the *A. minimus* group was at Davao where, at Mintol, we found a splenic index of only 9.7 per cent among Japanese school children who were living on an estate through which runs a stream breeding *A. minimus* larvæ. Due to the economic depression, Paris-green treatment of this stream had been discontinued for some months and larvæ were abundant. The low splenic index could be accounted for by the fact that these children and all laborers on this estate were compelled to use bed nets. There are no exceptions to this rule, and rigid supervision is carried out.

Elsewhere, as noted in the tables, malaria and the *A. minimus* group were always closely associated, but the mere fact of asso-

TABLE 16.—*Breeding places in which collections were made.*

Breeding place.	Times visited.
Streams	318
Rivers	77
Irrigation ditches	72
Pools, fresh water	40
Pools, salt water	22
Lakes	6
Rice fields	4
Wells	4
Ditch, still, unshaded	2
Swamp	1
Total collections	546

TABLE 17.—*Classification of breeding places.*

Breeding place.	Times visited.
Stream:	
Clear water	266
Muddy water	44
Shaded water	174
Unshaded water	38
River	77
Pool, fresh water	39
Lake	6
Rice field	4
Irrigation ditch	72
Well	4
Salt-water pool or pond	22
Other places:	
Ditch, unshaded	2
Swamp	1

TABLE 18.—*Breeding places of A. minimus and/or A. mangyanus.*

Breeding place.	Collections of *Anopheles minimus* and/or *A. mangyanus*.
Stream:	
Clear water	225
Muddy water	37
Shaded water	141
Unshaded water	23
Bamboo at edge	72
River:	
Clear water	47
Muddy water	7
Shaded water	32
Unshaded water	23
Bamboo at edge	17
Irrigation ditch:	
Clear water	36
Muddy water	9
Shaded water	14
Unshaded water	35
Other places:	
Pool—	
Stream, shaded, clear	2
Stream, unshaded, muddy	1
Shaded	2
Unshaded	1
Unshaded, bamboo roots	1
Well—	
Shaded, clear	1
Unshaded, clear	1

ciation with malaria is obviously not enough to prove that a mosquito is a malaria carrier. It must be remembered that in order to be a factor in the transmission of human malaria in any given region a species of *Anopheles* must obviously have certain characteristics. It must be distributed in sufficient numbers close enough to habitations. It must desire human in preference to animal blood and strongly enough to enter houses for meals. Finally, it must be susceptible to infection. Not a great deal is known about the interplay of these factors in the life history of Philippine anophelines.

The first requirement of density in numbers and proximity to habitations is fulfilled by a majority of the Philippine *Anopheles*. As to the second factor, very little information is available. Only the work of Laurel(51, 52) has been published. This observer found that thirty-one out of thirty-nine blood meals of

A. minimus (*"funestus"*) reacted for human and none for animal tests. The reverse was true of eight other species, including *A. barbirostris*. Of the latter, thirteen were tested; seven reacted to cow sera, none to human.

Anopheles minimus adults are rarely taken inside human habitations in the daytime, as noted by Russell,(53, 54) but large numbers may be trapped if a sleeping human is used for bait. See Manalang.(49, 55) Numbers have been caught in bed nets. See Barber et al.(1)

As to the final test; namely, the susceptibility to infection, a great deal more information is required. The first work to determine susceptibility was done by Banks,(56) who claimed to have experimentally infected *Myzomyia ludlowi*. Since his mosquitoes came from salt water they were probably of the species that King has named *A. litoralis* and which is so-called in our classification. This work was inconclusive for, as Manalang(45) points out, Banks may have been mistaken in his diagnosis of the sporozoites.

TABLE 19.—*Breeding places where larvæ of A. minimus but not A. mangyanus were taken.*

Breeding place.	Collections of *Anopheles minimus*.
Stream:	
Clear water	48
Muddy water	5
Shaded water	46
Unshaded water	4
Bamboo	15
River:	
Clear water	6
Muddy water	2
Shaded water	8
Unshaded water	1
Bamboo at edge	3
Irrigation ditch:	
Clear water	12
Muddy water	
Shaded water	2
Unshaded water	10
Pool:	
Stream, shaded, clear	1
Stream, unshaded, muddy	
Shaded	
Unshaded	3
Unshaded, bamboo	

TABLE 20.—*Breeding places where larvæ of A. mangyanus but not A. minimus were taken.*

Breeding place.	Collections of *Anopheles mangyanus.*
Stream:	
Clear water	13
Muddy water	1
Shaded water	13
Unshaded water	1
Bamboo	3
River:	
Clear water	4
Muddy water	1
Shaded water	3
Unshaded water	2
Bamboo at edge	2
Irrigation ditch:	
Clear water	1
Muddy water	
Shaded water	
Unshaded water	1
Pool:	
Stream, shaded, clear	1
Stream, unshaded, muddy	
Shaded	
Unshaded	1
Unshaded, bamboo	

The next studies of experimental infection were made by Walker and Barber.(57) Table 21 includes only strictly comparative figures and not the totals. Both gut and gland infections are included.

TABLE 21.—*Walker and Barber's summary of experimental malaria infections in Philippine Anopheles.*

Species.	Insects dissected.	Infected.	
		Number.	Per cent.
Anopheles febrifer [a]	162	108	66.7
Anopheles maculatus	3	2	66.7
Anopheles rossi [b]	187	35	18.7
Anopheles barbirostris	100	6	6.0
Anopheles sinensis	12	0	0.0

[a] *Anopheles febrifer* included what in our report is *A. mangyanus*, also *A. minimus* and perhaps *A. filipinæ*.

[b] *Anopheles rossi* probably included *A. litoralis*, *A. subpictus* v. *indefinitus*, *A. vagus*. *A. sinensis* is *A. hyrcanus* v. *sinensis*.

The remaining published evidence is that of Manalang.(45, 46, 47, 55, 58, 59) This observer in thousands of dissections of several Philippine species, including *A. barbirostris, A. fuliginosus, A. hyrcanus* var. *sinensis, A. karwari, A. maculatus, A. minimus* (*"funestus"*), *A. philippinensis, A. subpictus* var. *indefinitus* (*"rossi"*), *A. tesselatus,* and *A. vagus* has only found *A. minimus* infected. (Whether the infected individuals did or did not include *A. mangyanus* is uncertain.) On one occasion Manalang(60) found a wild-caught *A. maculatus* infected but this was after artificial incubation in a laboratory cage. On another occasion one heavily infected stomach was found in *A. vagus.*(55)

Therefore, all available evidence, at the present time, points to the *minimus* group as the chief vectors of malaria in the Philippines, but it would indeed be rash to assume that only this group is ever guilty in this Archipelago.

There is no evidence in our reconnaissance that salt-water *Anopheles* play any part in malaria transmission in the Philippines. Epidemiologically, our results tend to incriminate the *minimus* group above all others, but our tables do not rule out the distinct possibility that other species may occasionally be transmitting malaria.

SUMMARY AND CONCLUSIONS

This paper reports a malaria reconnaissance in two hundred fourteen towns or barrios in forty of the forty-eight provinces of the Philippine Islands. Five hundred forty-six separate collections of *Anopheles* larvæ were made, in which were found twenty-two of the twenty-four known Philippine species. These collections are analyzed as to type of breeding place, and frequency and associations of species. A discussion of the classification and biology of Philippine *Anopheles* is presented.

During this reconnaissance 1,237 blood-smear examinations were made. These are reported in the tables together with 7,869 spleen palpations. A discussion of spleen palpation in general and its application to malariometry in the Philippines is given.

There is also included a general discussion of climate and altitude in relation to malaria in the Philippines with appropriate maps and notes. As a result of our observations we conclude that:

1. Malaria is a serious and widespread disease in the Philippines, being prevalent from Ilocos Norte to Tawitawi and from Balabac to Samar.

2. This disease is not universally or uniformly present in the Archipelago. It is not prevalent along the low coastal plains, on the flat plateaus, or in the mountains above 2,000 feet. It is mildly endemic in some places, severely so in others, and hyperendemic in still others.

3. Malaria and the *minimus* group of *Anopheles* are almost always directly associated in the Philippines. This observation, taken together with published facts as to the prevalence of infected *minimus* mosquitoes both in nature and in laboratory experiments, leads us to suspect strongly that the chief vectors of malaria here are in the *minimus* group of *Anopheles*.

4. The *minimus* group of *Anopheles* breeds chiefly in streams, rivers, and irrigation ditches, more in shady than open places and in clear than muddy water. It distinctly prefers clean, fresh, flowing water. But this group is not restricted to these habitats. We have found it occasionally in still pools and in wells. We have never found it in salt water, in rice fields, or in any water at a higher altitude than 2,000 feet.

5. In the light of the above conclusions, it is not surprising that we also conclude that malaria in the Philippines is primarily a disease of foothills. It is found chiefly in two zones; namely, that between the coastal plain and higher ground and that between this higher ground and the mountains.

6. Altitudes of less than 2,000 feet, per se, have no marked influence on the prevalence of malaria in the Philippines. It is change of contour rather than altitude which directly affects malaria prevalence here. Above 2,000 feet malaria transmission apparently does not occur. Our evidence in this respect, although entirely consistent, is not yet great enough to permit a dogmatic statement.

7. With due regard to occasional cases of chicken pox, measles, and schistosomiasis, we conclude that spleen palpations give as good an index in the Philippines, as elsewhere, of the prevalence of malaria.

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ILLUSTRATIONS

PLATE 1

Climate map of the Philippine Islands, showing the seasons and the rainfall.

PLATE 2

Temperature map of the Philippine Islands.

PLATE 3

Map of the Philippine Islands, showing places visited during a malaria reconnaissance and the endemicity based on spleen index.

PLATE 4

Typical *Anopheles minimus* group breeding stream in Jolo, Sulu Province, showing partial shade and rapid flow of water; also the type of collecting dipper.

PLATE 5

An *Anopheles minimus* group breeding place along the bank of Cabiao River, Laguna Province, Luzon, showing partial shade, bamboo, and water hyacinth.

PLATE 6

FIG. 1. Santa Fe, Nueva Vizcaya Province, Luzon; altitude, 1,900 feet. Malaria is hyperendemic in this town. Note the stream.

2. The stream at Santa Fe immediately to the left of the area shown in the foreground of fig. 1. A breeding place of mosquitoes of the *Anopheles minimus* group.

PLATE 7

FIG. 1. A view, toward the north, from Puncan Barrio, Nueva Ecija Province, Luzon. The flat ricefield country stretching south from the edge shown in this photograph is not malarious, and does not breed *Anopheles minimus;* but Puncan is directly in the transition zone between this flat country and the mountains and is highly malarious. Its streams breed mosquitoes of the *A. minimus* group.

2. Coast line at Pasacao, Camarines Sur Province, Luzon. Note the proximity of foothills. This town is malarious.

3. Pathfinder Estate, Kabasalan, Zamboanga Province, Mindanao. The streams and ditches on this estate are breeders of the *A. minimus* group; and the estate, situated in the transition zone between coastal mangrove swamps and mountains, is malarious.

TEXT FIGURE

FIG. 1. Diagram of spleen sizes according to Boyd.

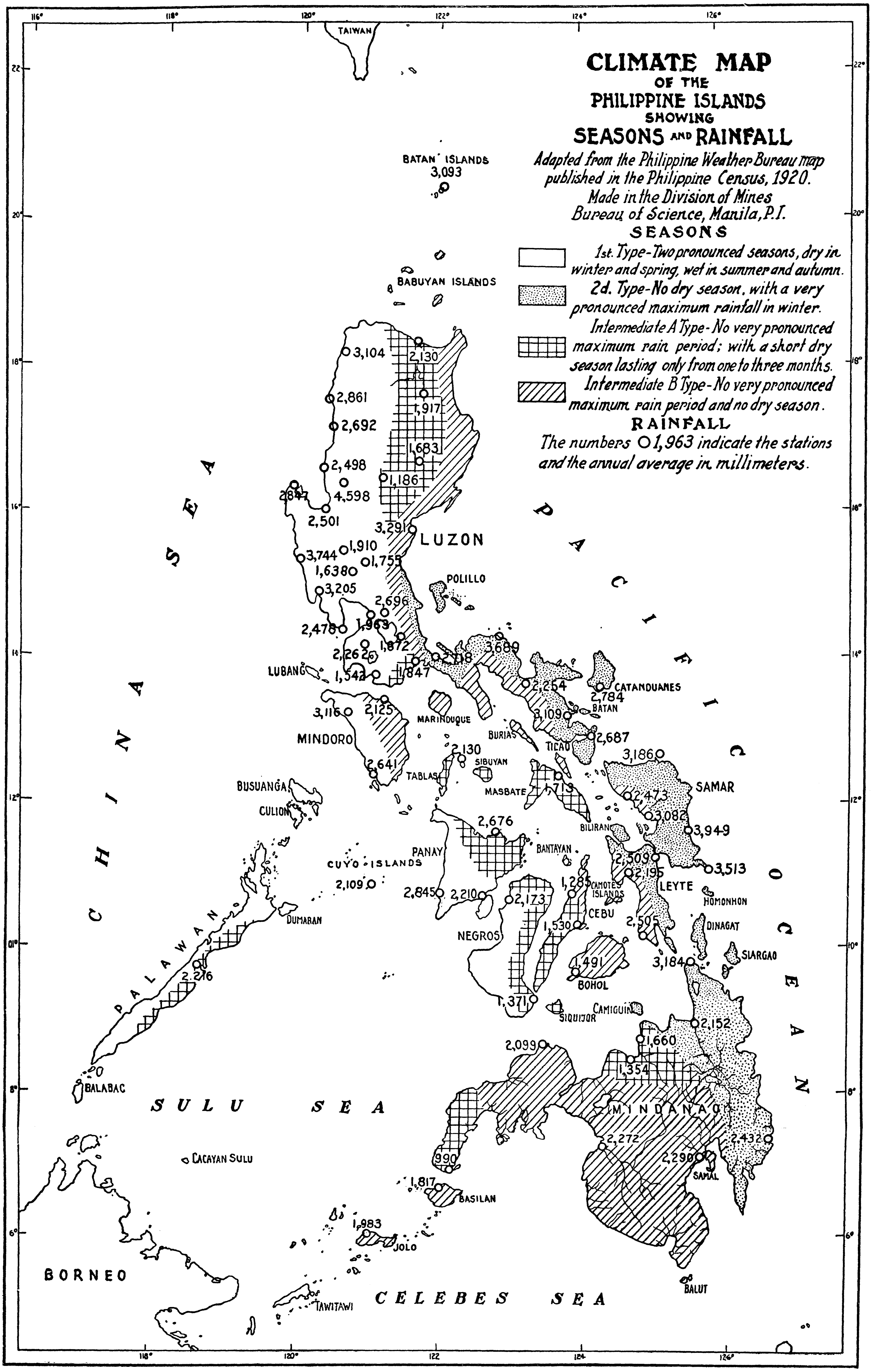

PLATE 1. CLIMATE MAP OF THE PHILIPPINE ISLANDS, SHOWING THE SEASONS AND THE RAINFALL.

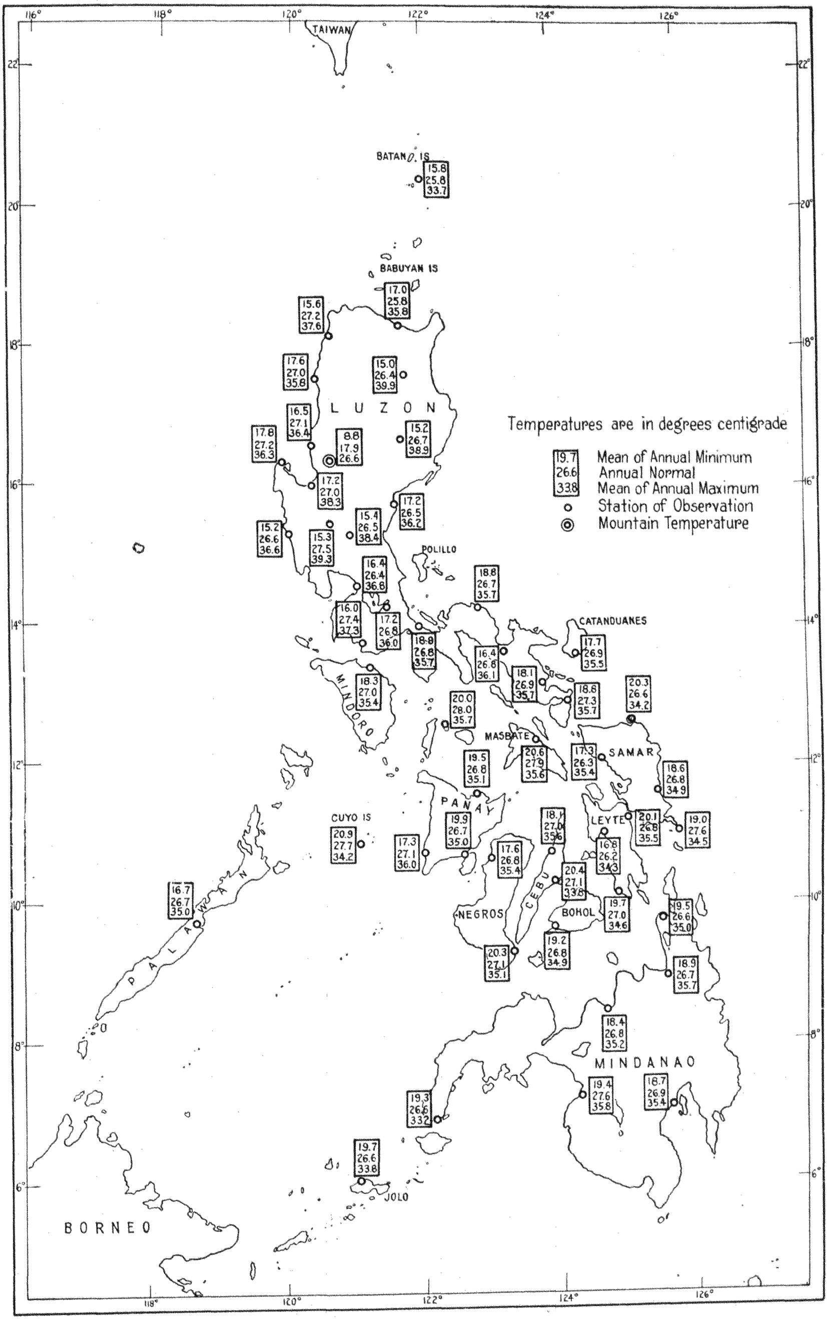

PLATE 2. TEMPERATURE MAP OF THE PHILIPPINE ISLANDS.

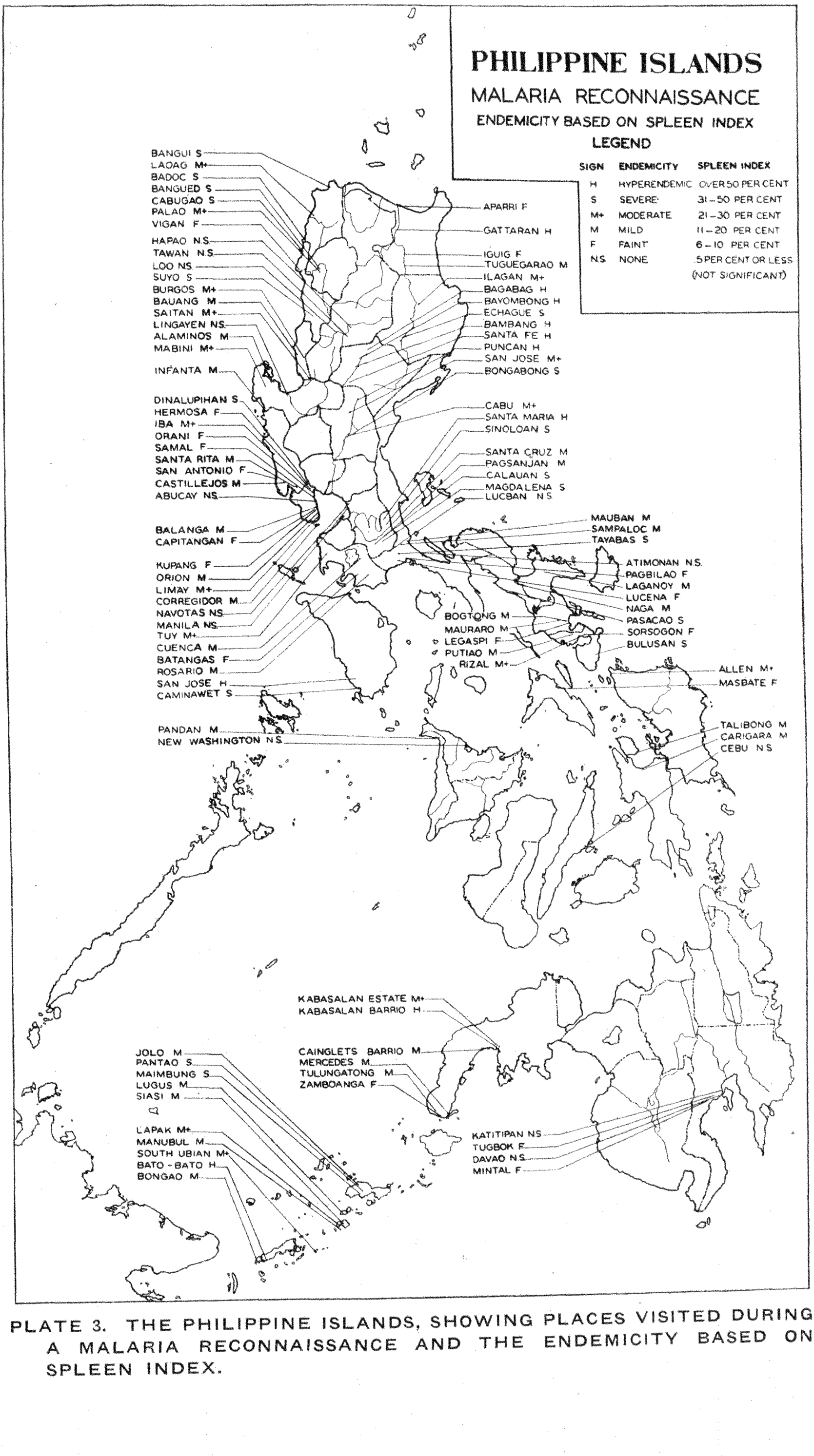

PLATE 3. THE PHILIPPINE ISLANDS, SHOWING PLACES VISITED DURING A MALARIA RECONNAISSANCE AND THE ENDEMICITY BASED ON SPLEEN INDEX.

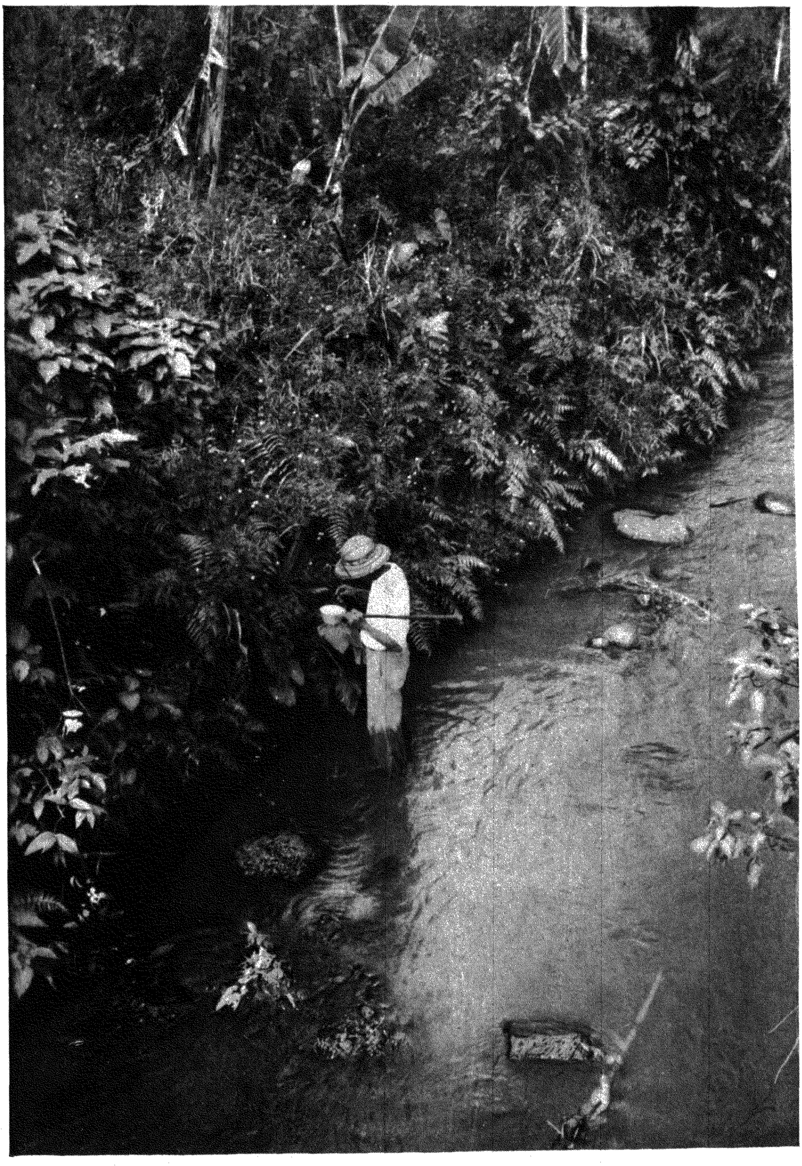

PLATE 4.

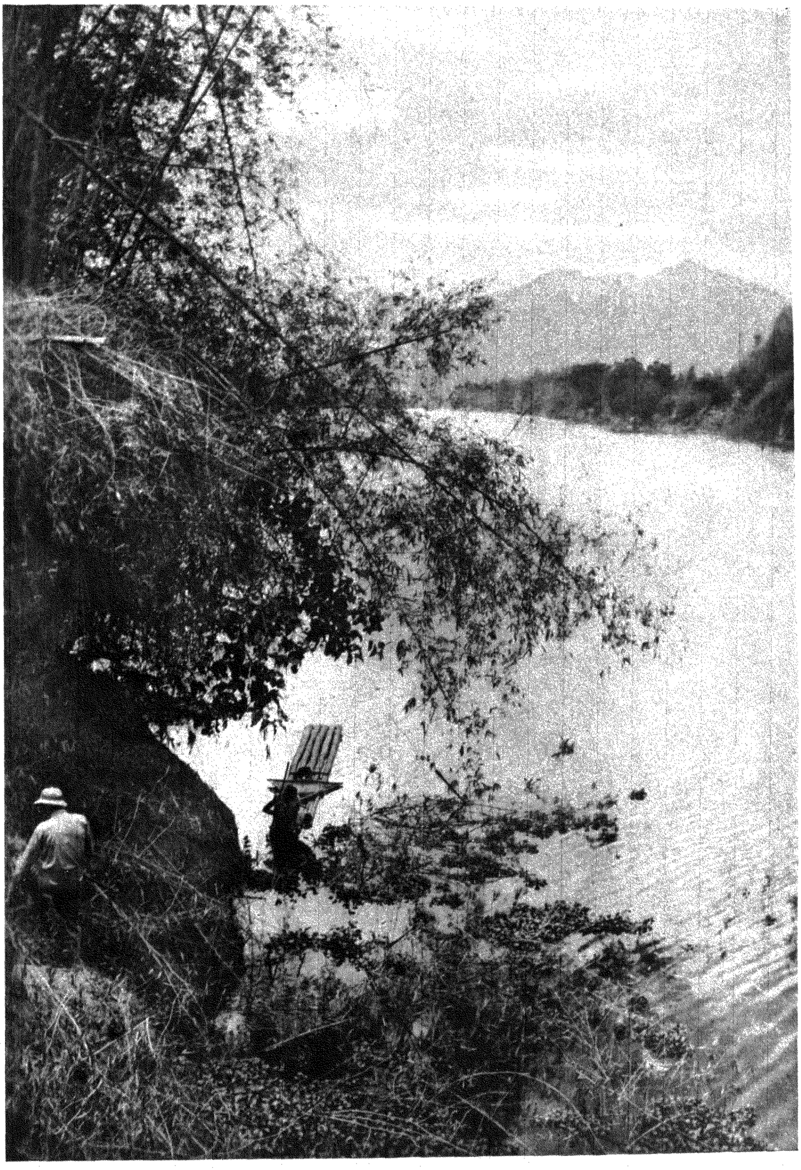

PLATE 5.

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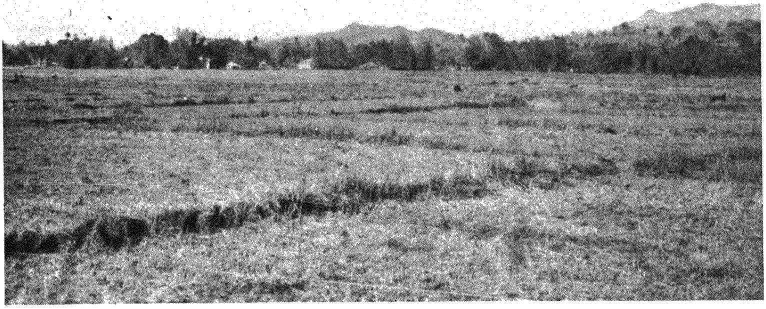
PLATE 6.



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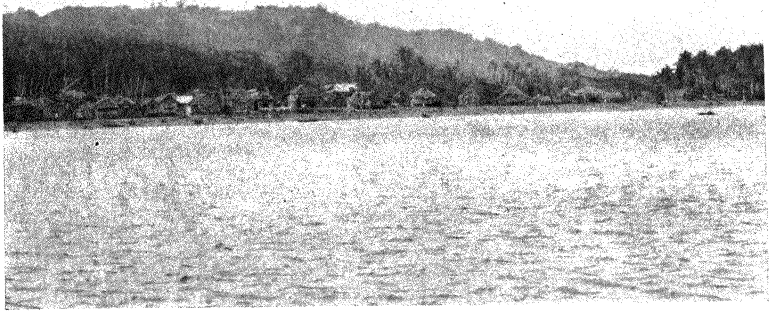

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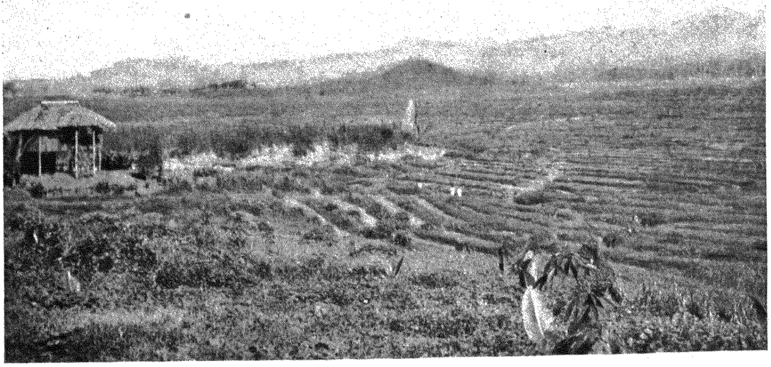

3

PLATE 7.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XI[1]

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

THREE PLATES

The very interesting crane flies discussed at this time were all taken at altitudes of between 3,500 and 11,000 feet on Mount Omei, Szechwan, western China, by the Reverend Mr. Franck. The genera and subgenera *Trichotipula, Macgregoromyia, Adelphomyia, Phyllolabis, Rhabdomastix, Gnophomyia,* and *Teleneura* are herewith added to the Chinese list. I wish to express my very deep thanks to Mr. Franck and Mr. Parish for the privilege of studying this exceptional series of Tipulidæ. All types are preserved in my collection.

TIPULINÆ

TIPULA (TRICHOTIPULA) POLYTRICHA sp. nov. Plate 1, fig. 1; Plate 2, figs. 23, 24, 25, 26.

General coloration of mesonotum black; thoracic pleura chiefly black; antennæ black, the basal two segments yellow; knobs of halteres yellow at apices; legs chiefly black; wings cream-colored, chiefly concealed by extensive brown seams on cord and other veins, and by darkened central areas in the primary basal cells; wing membrane with abundant macrotrichia in all cells almost to arculus; wing veins with a virtually complete series of trichia on all veins and crossveins; male hypopygium with the ninth tergite tridentate at tip; basistyle and tergite partly fused with the sternite.

Male.—Length, about 11 millimeters; wing, 12.3.

Frontal prolongation of head short and stout, testaceous brown; nasus short but distinct, blackened; palpi black. Antennæ (male) of moderate length, if bent backward extending about to root of halteres; scape and pedicel light yellow; flagellum black; basal enlargement of segments relatively small and little differentiated; verticils shorter than the segments; terminal

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[1] Contribution from the entomological laboratory, Massachusetts State College.

segment long-conical, about one-third as long as the twelfth. Front and anterior vertex yellow, the posterior portion of head dark brown, with abundant black setæ; vertical tubercle inconspicuous or lacking.

Pronotum brown. Mesonotum shiny black. Pleura brownish black, variegated with paler brown on the sutures, dorsopleural region, and meron; sternopleurite with setæ. Halteres brown, the apices of the knobs conspicuously light yellow. Legs with the coxæ brownish yellow, the posterior coxæ paler; trochanters obscure yellow; femora dark brown, the tips blackened; tibiæ and tarsi black. (A single leg, fore, remains, this with a single tibial spur.) Wings (Plate 1, fig. 1) broad; ground color cream-yellow, cells C and Sc somewhat deeper yellow; the ground largely obscured by broad brown seams to the veins and by longitudinal streaks in the centers of cells R, M, distal half of Cu, and the anal cells, that in 1st A widened outwardly; stigma dark brown, conspicuous; whitish obliterative areas before stigma and across cell 1st M_2; veins brown. Macrotrichia of cells very numerous, including the entire wing excepting the restricted bases of cells R, M, Cu, and 1st A (shown by stippled dots in the figure); cell Cu_1 without macrotrichia except beyond level of m-cu; abundant macrotrichia in the prearcular subcostal cell. Macrotrichia of veins long and conspicuous, including all longitudinal veins, deflections, and crossveins, as m, r-m, and m-cu; a series of trichia on basal portion of the semiatrophied vein Cu_2. Squama with a few long setæ that are scarcely to be differentiated from those of the anal fringe. Venation: Rs long; R_{1+2} entire; m-cu elongate; petiole of cell M_1 shorter than or about equal to m; cell 2d A of moderate width.

Abdominal tergites black, the caudal margins and midline of the intermediate segments yellowish; sternites more uniformly reddish yellow; outer segments, including hypopygium, dark brown. Male hypopygium (Plate 2, fig. 23) relatively small and generalized in structure. Basistyle, *b*, separated from the sternite, 9*s*, by a wide ventral suture, at near apex constricted and then widened into a glabrous portion that bears the dististyles. Ninth tergite (Plate 2, fig. 24, 9*t*) separated from the sternite by a membranous line on about the outer three-fourths, but entirely fused on cephalic portion; caudal portion of tergite not or only slightly projecting beyond the general level of the basistyles; caudal margin, as viewed from above, subtruncate, weakly lobed; median region with three decurved blackened teeth, the median one much smaller than the laterals.

Ninth sternite (Plate 2, fig. 25, 9*s*) very widely membranous beneath, with a narrow median notch, the ventral caudal angles produced into slender hairy lobes. Outer dististyle (Plate 2, fig. 26, *od*) relatively narrow, gently arcuated. Inner dististyle (Plate 2, fig. 26, *id*) with the posterior portion or "heel" terminating in a flattened oval glabrous blade, the cephalic portion a very slender blackened spine.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 11,000 feet, July 20, 1931 (*Franck*).

The very remarkable *Tipula* here described requires comparison with none of the known regional species of the complex. The presence of macrotrichia on all the veins and in virtually all the cells of the wing, including a prearcular group in cell Sc, is elsewhere unknown in the genus. I hesitate to propose a new subgeneric group on this insufficient material and prefer to place it, tentatively at least, in *Trichotipula* Alexander, the other known species of which are Nearctic. The degree of trichiation of the cells of the wing exceeds that of the better-known limoniine genera having hairy wings, as *Ula*, *Adelphomyia*, *Ulomorpha*, and even *Ormosia*.

TIPULA MUTILOIDES sp. nov. Plate 1, fig. 2; Plate 2, figs. 27, 28, 29, 30.

Allied to *mutila;* general coloration of mesonotum light gray, the præscutum with three darker gray stripes; setigerous punctures conspicuous; basal segments of antennæ light yellow, the remainder black; legs black, the femoral bases narrowly yellow; wings pale brown, variegated with large whitish areas; R_{1+2} lacking; abdomen yellow, the basal tergites trivittate with black, the outer segments more uniformly blackened; male hypopygium with the tergite divided by a narrow membranous pale line; eighth sternite projecting as a shovel-shaped structure.

Male.—Length, about 12 millimeters; wing, 11.5.

Frontal prolongation of head gray; nasus short and stout; palpi black. Antennæ of moderate length, if bent backward extending about to the base of abdomen; scape and pedicel light yellow, flagellum black, the base of first segment paler; basal enlargement of flagellar segments only moderately developed; verticils shorter than the segments; terminal segment small, subconical. Head gray.

Mesonotal præscutum light gray, with three darker gray stripes, the median stripe with a scarcely evident darker median vitta; interspaces with conspicuous brown setigerous punctures;

posterior sclerites of mesonotum light gray. Pleura, including the dorsopleural membrane, gray. Halteres buffy, the knobs dark brown. Legs with the coxæ gray; trochanters yellow; remainder of legs black, the femoral bases narrowly yellow; tibial spur formula 1–2–2; spurs long and straight, hairy; claws with basal tooth, the proximal half of each claw hairy. Wings (Plate 1, fig. 2) with the ground color pale brown, the prearcular region and cells C and Sc more yellowish; stigmal region somewhat darker brown; conspicuous whitish areas on wing disk, as follows: At near midlength of Rs, in both cells R_1 and R; an incomplete crossband beyond the cord, including cells R_2 to 1st M_2; a large suboval white area at near three-fourths the length of cell M; bases of cells Cu and 1st A whitened; veins brown, paler in the flavous areas. Macrotrichia of veins relatively long and conspicuous, including practically complete series on veins beyond cord; vein 1st A with only two or three trichia at extreme outer end; vein 2d A with trichia on distal two-thirds; Rs without trichia; squama bare. Venation: R_{1+2} atrophied; Rs elongate, nearly twice R_{2+3}; cell 1st M_2 relatively small, pentagonal.

Abdominal tergites light yellow, narrowly trivittate with black; on fifth and succeeding segments more extensively darkened so as to obscure the yellow color; basal sternites more uniformly yellow, the outer segments blackened. Male hypopygium (Plate 2, fig. 27) with the tergite, 9*t*, entirely separate from the sternite, 9*s*. Basistyle, *b*, almost completely separated from sternite by a suture that is broken near its ventral portion for about one-fourth its length. Ninth tergite (Plate 2, fig. 28, 9*t*) extensive, heavily blackened, entirely divided by a pale median line; apex of tergite more narrowed, the caudal margin with a very shallow V-shaped notch; dorsal surface of tergite with numerous small setæ. Outer dististyle (Plate 2, fig. 29, *od*) a very slender elongate rod. Inner dististyle (Plate 2, fig. 29, *id*) relatively narrow, the base projecting caudad as a densely setiferous lobule. Ninth sternite with a dense brush of black setæ lying in the sheathing concavity of the eighth sternite, the latter (Plate 2, fig. 30, 8*s*) projecting caudad as a prow-shaped or shovel-like structure, narrowed caudally, the apex narrowly pale and provided with numerous setigerous punctures.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 11,000 feet, July 29, 1931 (*Franck*).

Tipula mutiloides is allied to species such as *T. futilis* Alexander (Japan), *T. edwardsella* Alexander (Formosa), and others in the eastern Palæarctic fauna, differing most evidently in the structure of the male hypopygium and details of coloration of the body.

MACGREGOROMYIA SZECHWANENSIS sp. nov. Plate 1, fig. 3; Plate 2, figs. 31, 32.

Mesonotal præscutum buffy gray, with three brown stripes; antennæ relatively long; legs with tibiæ and tarsi black; wings with a brownish tinge, stigma and a broad seam on anterior cord dark brown; forks of medial field relatively shallow, cell M_1 less than twice the length of cell 1st M_2; inner dististyle of male hypopygium with the apical beak long and slender.

Male.—Length, about 8 millimeters; wing, 8.5.

Frontal prolongation of head short, buffy brown; palpi dark. Antennæ (Plate 2, fig. 31) with the scape, pedicel, and basal half of first flagellar segment light yellow, the remainder of organ black; flagellar segments long, cylindrical, with short verticils; basal enlargements of segments only slightly developed; flagellar segments beyond the second gradually decreasing in length. Head dark brown.

Mesonotal præscutum buffy gray with three brown stripes; posterior sclerites of mesonotum dark brown, the postnotum sparsely pruinose. Pleura buffy, variegated with dark brown on anepisternum, ventral sternopleurite, and meron. Halteres pale, the knobs infuscated. Legs with the coxæ pale, slightly infuscated basally; trochanters yellow; femora dark brown, the tips blackened; tibiæ and tarsi black. Wings (Plate 1, fig. 3) with a brown tinge, the prearcular and costal regions more yellowish; stigma and a broad seam on anterior cord dark brown; posterior cord and adjoining veins narrowly seamed with brown; more whitish areas before and beyond the stigma; veins dark brown. Macrotrichia of veins relatively long and conspicuous; a few macrotrichia in outer ends of cells R_3 and M_1. Venation: Sc_1 present; Rs with basal section transverse, in alignment with r-m, the second section of Rs short; R_{1+2} lacking; forks of medial cells relatively shallow; cell M_1 less than twice the length of cell 1st M_2.

Abdominal segments buffy brown, the basal ring narrowly blackened; outer segments, including hypopygium, more uniformly infuscated. Male hypopygium (Plate 2, fig. 32) with the lobes of the ninth tergite, *9t*, separated by a narrow notch, each lobe not evenly rounded at apex but provided with a very shallow notch on outer margin. Outer dististyle, *od,* long-oval, narrowed to the blunt apex. Inner dististyle, *id,* with the apical beak long and slender.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

The discovery of two new species of *Macgregoromyia* in western China is a matter of unusual interest, the only other species so far discovered being two that occur in the high mountains of northern Luzon. The two species described at this time are more closely related to *M. brevisector* Alexander, than they are to the genotype, *M. benguetensis* Alexander, having the short, perpendicular, basal section of the radial sector of the former species. The Chinese species differ most evidently in the uniformly blackened tibiæ and other details of coloration of the body and wings; *M. szechwanensis* is more generalized in structure than is either *M. brevisector* or *M. celestia* sp. nov.

MACGREGOROMYIA CELESTIA sp. nov. Plate 1, fig. 4; Plate 2, figs. 33, 34.

General coloration of mesonotum brown, the præscutum with three darker brown stripes; antennæ (male) short, the basal segments yellow, the remainder black; flagellar segments without basal enlargements and with very much reduced verticils that are placed at near midlength of the segments; legs brown; wings with a faint brownish tinge, the stigma and seams along cord, vein Cu_1, and marginally from stigma to wing apex brown; cell 1st M_2 small, about one-fourth as long as cell M_1; male hypopygium with the inner dististyle short and broad, with a small apical beak.

Male.—Length, about 11 millimeters; wing, 11.

Frontal prolongation of head light brown; nasus short but evident; palpi with the basal two segments brownish black, the third segment dark brown, the terminal segment paling to yellow. Antennæ (Plate 2, fig. 33) short; scape, pedicel, and first flagellar segment yellow, the remainder black; flagellar segments cylindrical, without indication of basal swelling, the segments gradually decreasing in length outwardly; verticils very small to scarcely evident, placed at near midlength of the segment; antennæ considerably shorter than in *szechwanensis.* Head light brown.

Mesonotum brown, the præscutum with three darker brown stripes, the median one becoming paler behind; humeral and lateral portions of præscutum somewhat more grayish; scutal lobes and scutellum dark brown. Pleura brown, darker on the ventral anepisternum. Halteres long, the stem pale, the knobs dark brown. Legs very long and slender; coxæ darkened basally, their apices light yellow, most extensive on the posterior coxæ; trochanters pale yellow; remainder of legs brown, the femoral bases slightly brightened; claws small and nearly simple, each bearing a broad tooth near base. Wings (Plate 1, fig. 4) with a faint brownish tinge, cells C and Sc more yellowish brown; stigma oval, dark brown; a clearly defined brown seam along cord; narrow seams along vein Cu and in outer end of cell R_2, extending along wing margin to beyond apex; veins black. Macrotrichia of veins beyond cord long and conspicuous; anal veins without trichia; no trichia in cells of wings. Venation: Sc_1 apparently lacking; Rs with basal section nearly perpendicular, fully twice the second section; R_{1+2} preserved as a short, erect spur; cell 1st M_2 very small, only about one-fourth as long as cell M_1.

Abdominal tergites chiefly dark brown, a trifle more brightened sublaterally just before caudal margin; sternites yellow, with a narrow brown basal ring; outer abdominal segments, including hypopygium, more uniformly dark brown. Male hypopygium having the general structure of the genus; inner dististyle (Plate 2, fig. 34, *id*) of quite different conformation from that of *szechwanensis*, being broad, its apical beak small.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

Macgregoromyia celestia is readily told from *M. szechwanensis* sp. nov. by the larger size, short antennæ, and very different wing venation, cell 1st M_2 being unusually small when compared to cell M_1. In its general appearance, the present fly is somewhat more like *M. brevisector* Alexander (Luzon), yet quite distinct in the venation and in the pattern of the legs and wings.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) FRANCKI sp. nov. Plate 1, fig. 5; Plate 2, fig. 35.

General coloration gray, the præscutum with a median brown stripe; knobs of halteres orange; legs black, only the femoral bases narrowly light yellow; wings with a heavy brown pattern, cells C and Sc uniformly infuscated; m-cu more than its own length before the fork of M; male hypopygium with the tergite profoundly split by a median incision, the lobes densely hairy; ventromesal lobe of basistyle very long and conspicuous; mesal-apical lobe of gonapophysis long and slender.

Male.—Length, about 7 millimeters; wing, 8.2.

Female.—Length, about 7 millimeters; wing, 7.8.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, with short, inconspicuous verticils; terminal segment from one-third to one-fourth longer than the penultimate. Head brownish gray, the center of vertex somewhat darker; anterior vertex a little less than twice the diameter of the scape.

Pronotum dark brown. Mesonotum gray, the præscutum with a conspicuous dark brown median stripe that becomes obsolete before the suture; lateral stripes obsolete or nearly so. Pleura gray, sparsely variegated with darker areas where the bloom has been denuded. Halteres pale, the knobs orange. Legs with the coxæ gray, vaguely brightened at tips; trochanters yellow; femora black, the bases narrowly light yellow, this equaling about one-fifth to one-sixth the total length of the segment; tibiæ and tarsi black; claws long and slender, with a long basal spine and microscopic denticles at extreme base. Wings (Plate 1, fig. 5) relatively narrow; ground color pale yellow, the prearcular region more intensely yellow; cells C and Sc uniformly dark brown; a heavy solidly dark brown pattern, distributed as follows: A quadrate area at origin of Rs, entirely crossing cell M; a very extensive seam along cord, extending from the stigma entirely across the wing; outer end of cell 1st M_2 narrowly seamed; extensive darkenings in outer ends of anal cells, most extensive in 2d A where the outer two-thirds of the cell is included; wing margin narrowly seamed with brown; veins brown. Venation: Sc_1 ending about opposite two-fifths the length of Rs, Sc_2 close to its tip; free tip of Sc_2 and R_2 in transverse alignment; R_{4+5} elongate, subequal to or exceeding R_{2+3}; cell 1st M_2 about as long as vein M_{1+2} beyond it; m-cu a little more than its own length before the fork of M; cell 2d A of moderate width, the anal veins parallel at origin.

Abdomen black, gray pruinose, the basal sternite more yellowish; caudal margins of sternites narrowly ringed with pale. Male hypopygium (Plate 2, fig. 35) with the tergite, 9*t*, profoundly divided by a linear median incision, the very broad lobes thus formed darkened and provided with very numerous, long, coarse setæ that are more abundant near the midline, becoming fewer toward the lateral margin. Basistyle, *b*, relatively small but with a very large ventromesal lobe that in a position of rest on a microscope slide extends caudad almost to the apex of the ventral dististyle, provided with numerous setæ, those of mesal face near apex very long, erect, light yellow. Ventral dististyle, *vd,* fleshy, the rostral prolongation pendant, narrowed apically, the two rostral spines placed at its base, nearly straight, lying flat against surface of style. Gonapophyses, *g,* with the mesal-apical lobes narrowed to a slender, gently curved spine.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 11,000 feet, July 18, 1931 (*Franck*). Allotopotype, female, altitude 11,000 feet, July 30, 1931.

This very distinct fly is named in honor of the collector as a slight appreciation of his efforts in making known the crane flies of western China. The unusual male hypopygium, in conjunction with the basal position of m-cu, furnishes characters that render it unnecessary to compare the fly with any of its distant relatives. The structure of the rostral prolongation of the male hypopygium vaguely suggests that of *Limonia* (*Dicranomyia*) *sordida* (Brunetti) and allies, but the present species is a member of the typical subgenus *Limonia.*

LIMONIA (LIMONIA) LATICELLULA sp. nov. Plate 1, fig. 6.

General coloration gray, the præscutum with three dark brown stripes; antennæ black throughout, the basal flagellar segments subglobular; femora yellowish brown, the tips narrowly blackened; wings broad, whitish, this color including the broad prearcular region, the disk heavily patterned with brown and gray; m-cu oblique in position, placed a short distance before fork of M; cell 2d A very broad.

Female.—Length, about 7 to 9 millimeters; wing, 7.2 to 11.

Rostrum black, pruinose; palpi black. Antennæ black throughout; basal flagellar segments subglobular to very short-oval, the outer segments passing to oval; verticils shorter than the segments. Head blackish, sparsely pruinose; anterior vertex narrow.

Mesonotum gray, the præscutum with three dark brown stripes, the median one not reaching the suture; scutal lobes dark brown. Pleura gray, this color including the dorsopleural region. Halteres whitish. Legs with the coxæ dark, gray pruinose; femora obscure yellow, the tips narrowly but conspicuously blackened, the amount not exceeding the distal eighth of the segment; tibiæ brownish yellow, the tips narrowly brownish black, the degree of darkening less than that of the femoral tips; tarsi yellow to brownish yellow, the outer segments dark brown. In the Pehlinting paratype, the femoral tips are a little broader and the tibiæ more uniformly darkened. Wings (Plate 1, fig. 6) broad, the ground color white, including the broad prearcular region; a heavy brown and gray pattern, distributed as follows: Bases of cells C and Sc darkened, the latter more extensively so; brown areas at arculus, origin of Rs, at fork of Sc, stigma, along cord, and on outer end of cell 1st M_2; vague, paler, more-grayish clouds in the cubital and outer radial and medial cells; very large, grayish brown areas in the outer ends of both anal cells, that in cell 2d A being so extensive as to include all but the basal third of cell; veins dark brown, costa more yellowish, the prearcular veins paler. Venation: Sc_1 ending about opposite midlength of Rs, Sc_2 near its tip; Rs angulated and sometimes spurred at origin (including type); free tip of Sc_2 and R_2 in transverse alignment; m-cu oblique, approximately one-fourth to one-third its own length before fork of M; cell 2d A very wide.

Abdomen brownish black, the margins of the segments narrowly but conspicuously paler, gray. Ovipositor with the cerci slender and nearly straight; all valves dark reddish horn-color.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 11,000 feet, July 18, 1931 (*Franck*). Paratopotypes, 2 females, altitude 7,000 feet, July 17, 1931; 1 female, Pehlinting, Mount Omei, altitude 6,000 feet, July 1931.

The nearest ally of the present fly seems to be *Limonia* (*Limonia*) *francki* sp. nov., which has a somewhat similar wing pattern but is readily told by the blackened legs, the narrow wings, with m-cu far before the fork of M, and other characters. The Pehlinting paratype of the present species is much smaller than the type and differs somewhat in the coloration of the legs, as described.

LIMONIA (LIMONIA) BICORNIGERA sp. nov. Plate 1, fig. 7; Plate 2, fig. 36.

General coloration reddish yellow, the thoracic pleura with a dark brown longitudinal stripe; antennal segments with short, glabrous, apical necks; femora brownish black, the tibiæ and tarsi paler brown; wings tinged with brown; Sc_1 ending just beyond midlength of Rs; male hypopygium with the dististyle single, its rostral prolongation developed into a powerful, blackened, spinelike rod that narrows to an acute tip.

Male.—Length, about 5 millimeters; wing, 5.8.

Female.—Length, about 5.5 millimeters; wing, 6.2.

Rostrum dark brown; palpi brownish black. Antennæ black throughout; flagellar segments short-oval, becoming smaller and more elongate-oval outwardly, the segments with short, stout, glabrous, apical necks; verticils shorter than the segments; terminal segment a little longer than the penultimate. Head gray, the anterior vertex reduced to a linear strip in both sexes.

Pronotum dark brown. Mesonotum light reddish yellow to yellowish testaceous, without distinct markings. Pleura yellow, with a conspicuous, dark brown, longitudinal stripe extending from the propleura across the central sclerites, passing beneath the wing root to abdomen. Halteres pale yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora brownish black, the bases obscure yellow; in female, the femora more extensively pale; tibiæ and tarsi light brown, the outer tarsal segments darker; claws with a single, slender, subbasal spine, with additional more basal spinous setæ. Wings (Plate 1, fig. 7) with a brownish tinge; stigma subcircular, darker brown; veins brown. Venation: Sc_1 ending just beyond midlength of Rs, Sc_2 at its tip; free tip of Sc_2 and R_2 in approximate transverse alignment; m-cu close to fork of M; anal veins gently convergent beyond level of anal crossvein, thence sinuous to margin.

Abdomen brownish black, the basal sternites more brownish yellow; hypopygium dark. Male hypopygium (Plate 2, fig. 36) with the caudal margin of tergite, *9t*, gently emarginate. Basistyle, *b*, with the ventromesal lobe broad. A single dististyle, *d*, the body of which is a small oval setiferous lobe; rostral prolongation a powerful, heavily sclerotized spinelike rod that gradually narrows to a gently decurved acute point; surface of prolongation with setæ scattered over its entire length but without rostral spines. Gonapophyses, *g*, blackened and unequally bifid at tips. Apical lateral angles of ædeagus prolonged into narrow points. Ovipositor with the cerci relatively small, slender, strongly upcurved; hypovalvæ powerful, straight, dark horn-color, blackened basally.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*). Allotopotype, female. Paratopotype, female.

Limonia (*Limonia*) *bicornigera* is most nearly allied to the eastern Asiatic *L.* (*L.*) *machidai* (Alexander), agreeing in the general appearance and fundamentals of structure of the hypopygium. It differs from this species and from all other members of the subgenus known to me by the powerful, acutely pointed, rostral prolongation of the dististyle.

LIMONIA (DICRANOMYIA) SUBLIMIS sp. nov. Plate 1, fig. 8; Plate 2, fig. 37.

Belongs to the *pulchripennis* group; general coloration black, the thorax variegated by areas of yellowish gray pollen; wings white, with a heavy brown pattern, including about five costal areas that are solidly darkened in the costal and subcostal fields but with conspicuous white centers in cell R; male hypopygium with two spines on the rostral prolongation of the ventral dististyle.

Male.—Length, about 7 millimeters; wing, 8.3.

Female.—Length, about 8 millimeters; wing, 8.5.

Rostrum and palpi black. Antennæ with the scape black, the remaining segments dark brown; flagellar segments oval, the outer segments more elongate-oval, the verticils subequal to or shorter than the segments. Head grayish brown, the narrow anterior vertex more yellowish gray; a blackish area on either side of the narrow median line on the anterior portion of the posterior vertex.

Mesonotal præscutum yellowish gray, with three conspicuous black stripes, the median stripe broad and complete, the lateral stripes small; lateral margins of sclerite blackened; posterior sclerites of mesonotum blackish. Pleura variegated with black and yellowish gray pollinose areas. Halteres almost white, the knobs blackened. Legs with the coxæ and trochanters black; femora yellow, the tips broadly and conspicuously blackened; tibiæ yellow, the bases blackened, the amount about equal to one-half the femoral apex; tips of tibiæ blackened; tarsi black, the proximal third of basitarsi paler; claws long, with a single slender basal spine, with additional microscopic denticles nearer the base. Wings (Plate 1, fig. 8) with the ground color white, the prearcular region light yellow; a very heavy brown pattern, including about five costal areas that are much wider than the interspaces, the third area at origin of Rs, the fourth at stigma; all costal areas solidly darkened in cells C and Sc, the first four with conspicuous white centers where they occupy the radial field; costal darkenings not narrowed posteriorly (as is the case in *frivola* and *shirakii*); wing apex solidly but not quite so intensely darkened; narrower clouds along cord and outer end of cell 1st M_2; more grayish brown clouds in medial field and as large areas at ends of veins Cu_1, 1st A, and 2d A, the latter more intensely darkened at their margins; a further pale gray wash across the middle of the anal cells; veins pale, brown in the darkened areas. Venation: Sc_1 ending about opposite one-third to one-fourth the length of Rs, Sc_2 apparently lacking; m-cu about one-third or more of its length before the fork of M; cell 2d A of moderate width.

Abdomen black, the caudal margins of the segments very narrowly paler; hypopygium dark. Male hypopygium (Plate 2, fig. 37) with the rostral prolongation of the ventral dististyle, *vd,* very short and stout, with two spines that exceed in length the entire prolongation, these spines placed close together on the summit of the prolongation. Gonapophyses, *g,* with the mesal-apical lobe relatively slender and gently curved.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 11,000 feet, July 18, 1931 (*Franck*). Allotopotype, female, altitude 11,000 feet, July 17, 1931.

The *pulchripennis* group of *Dicranomyia* includes several unusually handsome species, all having the body coloration black, variegated with yellowish gray, the knobs of halteres blackened, the tips of femora and bases and tips of tibiæ conspicuously blackened, and with a heavy brown wing pattern that includes several costal areas. The group divides into two subgroups, of which the typical one, including *pulchripennis* (Brunetti), of northern India and western China, and *subpulchripennis* Alexander, of western China, have the intermediate dark marginal areas of the front part of wing variegated by pale centers in the costal cell and have a single elongate spine on the rostral prolongation of the male hypopygium. The second subgroup, including the present fly, *frivola* Alexander, of Formosa, *kirishimana* Alexander, of southern Japan, and *shirakii* (Alexander), of Formosa, have the marginal areas solidly darkened in cell C and with two spines on the rostral prolongation of the male hypopygium. The present fly is closest to *kirishimana* in its general characters, differing most evidently in the larger size, clear white centers of the intermediate costal areas of the wing, where these latter occupy cell R, and by the narrowly darkened seams to the clouded areas along the anal margin of wing.

HELIUS (HELIUS) INFIRMUS sp. nov. Plate 1, fig. 9; Plate 3, fig. 38.

Allied to *tenuistylus;* general coloration dark brown; legs dark brown, the tarsi paling to brownish yellow; wings with a strong grayish brown suffusion, the stigma darker; costal fringe (male) short; Rs only a little shorter than its anterior branch.

Male.—Length, about 7.5 millimeters; wing, 7.

Rostrum about one-fourth longer than the remainder of head, brownish black; palpi black. Antennæ short, black throughout; flagellar segments oval, becoming more elongate-oval outwardly; outer verticils much exceeding the segments. Head blackish.

Pronotum, mesonotum, and pleura dark brown, the ventral pleurites a little more brightened. Halteres dark brown. Legs with the coxæ and trochanters brownish testaceous; femora and tibiæ chiefly dark brown; narrow tips of tibiæ and most of tarsi paling to brownish yellow. Wings (Plate 1, fig. 9) with a strong grayish brown tinge, cells C and Sc somewhat darker; stigma elongate, still darker brown; veins brownish black. Costal fringe (male) short. Venation: Sc_1 ending just before the fork of Rs, Sc_2 near its tip; Rs relatively long, only a little shorter than its anterior branch; second section of M_{1+2} a little longer than the oblique m, so the inner end of cell 2d M_2 lies proximad of that of cell M_3; m-cu shortly before fork of M.

Abdominal tergites brownish black, the basal sternites obscure brownish yellow, the outer segments darker. Male hypopygium (Plate 3, fig. 38) with the mesal face of basistyle, *b,* near base with a conspicuous spiniferous lobe. Outer dististyle, *od,* gently curved, blackened, the apex very indistinctly toothed.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, July 17, 1931 (*Franck*).

Helius (*Helius*) *infirmus* is most nearly allied to *H.* (*H.*) *costofimbriatus* Alexander (Riukiu Islands) and *H.* (*H.*) *tenuistylus* Alexander (Formosa) in the venation and general structure of the male hypopygium. It differs from the former in the short costal fringe of the male sex; from the latter species it differs chiefly in the long Rs and slight details of the male hypopygium.

ANTOCHA (ANTOCHA) CONSTRICTA sp. nov. Plate 1, fig. 10; Plate 3, fig. 39.

General coloration gray; antennæ dark brown throughout; flagellar segments elongate-oval, the outer ones becoming smaller; femora yellow, the tips infuscated; wings milky white, the stigma barely indicated; cell 1st M_2 long, m-cu at fork of M; male hypopygium with each gonapophysis bearing a small lateral spine near apex; arms of phallosome powerful, each bearing a strong curved spine on mesal face at midlength.

Male.—Length, about 5 to 5.3 millimeters; wing, 6 to 6.2.

Rostrum and palpi brown. Antennæ dark brown throughout; flagellar segments elongate-oval, the outer segments becoming smaller and shorter, the terminal segment about two-thirds as long as the penultimate; verticils small and inconspicuous. Head light gray.

Pronotum brownish yellow, narrowly dark brown medially. Mesonotum gray, the humeral region restrictedly obscure yellow. Pleura, including pleurotergite, obscure yellow, very sparsely pruinose. Halteres pale, the knobs weakly infuscated. Legs with the coxæ and trochanters obscure yellow, the fore coxæ a trifle darker; femora yellow, the tips rather broadly and conspicuously infuscated; tibiæ yellow, the tips insensibly darkened; tarsi yellow, the outer segments brown. Wings (Plate 1, fig. 10) milky white, the prearcular region even clearer white; stigma barely indicated; veins brown, paler at the wing base. Anal angle of wing moderately developed. Venation: R_{2+3} only a trifle longer than R_{4+5}; cell 1st M_2 long, exceeding in length any of the veins beyond it; m-cu at fork of M, the distal section of Cu_1 more than one-third longer than m-cu.

Abdominal tergites brown, the basal sternites more yellowish; hypopygium dark. Male hypopygium (Plate 3, fig. 39) with the tergite, 9*t*, transverse, unusually narrow, the posterior margin constricted at near midlength, the greatest width (transverse) being about six times the length at narrowest point (longitudinal); tergal setæ numerous but confined to the caudal half of the segment, the more lateral setæ larger and powerful. Dististyles nearly terminal in position, the outer, *od*, shorter, the distal half heavily blackened, the apex obliquely truncated so the lower apical angle is subacute. Gonapophyses, *g*, long and slender, pale, before apex on outer margin with a slender spine that is not more than one-half as long as the stouter axial point. Phallosome, *p*, appearing as a somewhat lyrate plate, each arm stout and powerful, at near midlength on mesal face bearing a stout curved spine; outer margin near this same point with a small tubercle, larger and more conspicuous in the paratype than in the holotype figured.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*). Paratopotype, male.

The branched gonapophyses and arms of phallosome of the hypopygium separate the present species from all regional allies, with the exception of *Antocha* (*Antocha*) *multidentata* sp. nov., which is most readily told by genitalic characters.

ANTOCHA (ANTOCHA) MULTIDENTATA sp. nov. Plate 3, fig. 40.

General coloration of mesonotum brown, sparsely pruinose, the lateral margins of the præscutum obscure yellow; antennæ dark throughout; knobs of halteres weakly infumed; legs obscure yellow, the outer tarsal segments darkened; wings whitish subhyaline, sparsely variegated with darker; m-cu close to fork of M; male hypopygium with both the gonapophyses and lateral arms of phallosome bearing small lateral spines.

Male.—Length, about 4.5 to 5.2 millimeters; wing, 5 to 5.8.

Female.—Length, about 6 millimeters; wing, 6.5.

Rostrum light brown; palpi brown. Antennæ dark brown throughout; flagellar segments oval, with very small, inconspicuous verticils. Head dark brownish gray.

Mesonotal præscutum chiefly covered by three brown stripes that are confluent or nearly so, the lateral margins and median area before the suture obscure yellow; posterior sclerites of notum dark brown, sparsely pruinose. Pleura obscure yellow, vaguely marked with darker on the ventral sternopleurite. Halteres pale, the knobs weakly infuscated. Legs with the fore coxæ darkened, the remaining coxæ and all trochanters yellow; remainder of legs obscure yellow, the outer tarsal segments more infuscated. Wings whitish subhyaline, the stigma and vague seams to most of the longitudinal veins slightly darker than the ground color, the seams most evident as darkened veins inclosed by somewhat paler brown margins; costal region clearer yellow; veins pale, those beyond cord, Cu, 2d A, and outer half of 1st A somewhat darker. Venation: R_2 lying opposite or slightly distad of r-m; cell 1st M_2 as long as or slightly longer than the cells beyond it; m-cu at or a very short distance before the fork of M.

Abdominal tergites dark brown, the caudal margins a trifle paler; sternites a little paler brown than the tergites; subterminal segments a trifle darker than the base; hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 40) with the tergite, 9*t*, transverse, the caudal margin gently emarginate. Outer dististyle, *od*, relatively short, the outer end blackened, the apex very obliquely truncated, so the extreme tip is subacute. Gonapophyses, *g*, branched near outer end, the axial spine being longer and stouter than the weak lateral spine, the reverse of the condition obtaining in species such as *constricta* and *spiralis*. Arms of phallosome, *p*, somewhat lyriform, narrowed to acute points, on margin at about one-third the length bearing a slender acute branch.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, August 17, 1931 (*Franck*). Allotype, female, altitude 7,000 feet, July 17, 1931. Paratypes, 2 males, with the allotype; 1 male, altitude 3,500 feet, August 16, 1931.

Antocha (*Antocha*) *multidentata* is readily told from all regional species by the structure of the male hypopygium. The most similar species is *A.* (*A.*) *constricta* sp. nov., which has a very different conformation of the outer structures of the phallosome.

ANTOCHA (ANTOCHA) SPIRALIS sp. nov. Plate 3, fig. 41.

General coloration gray; antennæ black throughout, short; halteres and legs brown; wings gray, the prearcular region milky white; abdomen brownish black, the hypopygium brighter; male hypopygium with the gonapophyses branched near tips; lateral arms of phallosome slender, simple, before apex twisted into a complete spiral turn.

Male.—Length, about 4 millimeters; wing, 4.5.

Rostrum yellowish brown; palpi black. Antennæ black throughout, short, if bent backward not attaining the wing root; flagellar segments short-oval, the verticils short and inconspicuous. Head broad, dark gray.

Mesonotum and pleura uniformly dark gray. Halteres brownish black, the base of stem narrowly pale yellow. Legs with the coxæ yellow, the fore and middle coxæ more infuscated; trochanters obscure yellow; femora brown; tibiæ and tarsi dark brown to brownish black. Wings grayish, the prearcular region milky white; veins brown. Venation: Cell 1st M_2 relatively small; m-cu a short distance before the fork of M.

Abdomen brownish black, the disk of the basal two tergites vaguely brighter; hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 41) with the outer dististyle, *od*, moderately sclerotized, the apex obtuse. Gonapophyses, *g*, very slender, with a subterminal spine on outer margin, this much smaller and weaker than the inner or axial branch. Lateral arms of phallosome, *p*, simple, very slender, before apex twisted into a complete spiral turn.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, August 17, 1931 (*Franck*).

The curious conformation of the lateral arms of the phallosome of the male hypopygium suffices to distinguish the present fly from all of its now numerous regional allies. There are now more than a score of species of *Antocha* in Japan and China, with no fewer than nine distinct forms occurring on the single peak, Mount Omei.

ANTOCHA (ANTOCHA) NIGRIBASIS sp. nov. Plate 1, fig. 11; Plate 3, fig. 42.

General coloration pale yellow, including the head, thorax, abdomen, and halteres; legs yellow, the tips of the femora narrowly brownish black; wings milky white, the prearcular region and areas on the wing disk brownish black; R_2 lying far basad of r-m; m-cu about one and one-half times its own length before the fork of M; male hypopygium with the phallosome asymmetrical, consisting of a single elongate spine subtending the ædeagus.

Male.—Length, about 4.5 to 4.7 millimeters; wing, 5 to 5.3.

Rostrum yellow; palpi pale basally, the outer segments passing into brown. Antennæ short, pale yellow; flagellar segments oval, the longest verticils about equal to the segments. Head pale yellow.

Thorax pale yellow, the scutal lobes very weakly darkened. Halteres pale yellow. Legs pale yellow, the tips of the femora narrowly and conspicuously dark brown to brownish black; in one paratype, the tips of the tibiæ are similarly darkened but somewhat more narrowly so; outer tarsal segments darkened; claws with a small tooth at base. Wings (Plate 1, fig. 11) milky white, handsomely variegated with brownish black, as follows: Prearcular cells; a cloud at origin of Rs; stigma; narrow seams along cord, m-cu, outer end of cell 1st M_2, and along the veins issuing from cell 1st M_2, the dark color beyond cord being indicated mostly by the darkened veins; veins pale, brown in the darkened areas; costal region brighter yellow. Venation: R_2 only a little shorter than R_{2+3}, the latter about one-third R_{4+5}, R_2 thus lying far proximad of r-m; veins issuing from cell 1st M_2 divergent; m-cu more than one and one-half times its own length before the fork of M.

Abdomen yellow. Male hypopygium (Plate 3, fig. 42) with the tergite, *9t*, transverse, the caudal end gently emarginate and weakly crenulate, with numerous setæ. Dististyles subterminal in position, the outer, *od*, a sclerotized, ribbonlike blade. Gonapophyses, *g*, appearing as straight, simple blades, their tips acute. Phallosome, *p*, appearing asymmetrical, consisting of a single curved spine subtending the elongate ædeagus.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,000 feet, July 14, 1931 (*Franck*). Paratopotypes, 2 males, with type; 1 male, August 10, 1931.

Antocha (*Antocha*) *nigribasis* is very distinct from all other described regional species of the genus in the pale yellow coloration of the body, in conjunction with the narrowly blackened tips of the femora, the darkened wing bases, the proximal position of m-cu, and the structure of the male hypopygium.

ANTOCHA (ANTOCHA) BIDENS sp. nov. Plate 1, fig. 12; Plate 3, fig. 43.

General coloration yellow, the præscutum with four brownish gray stripes, the lateral pair crossing the suture onto the lateral portions of the scutal lobes; postnotal mediotergite dark, the cephalic lateral portions pale; pleura and pleurotergite yellow, variegated with brown; wings white, the longitudinal veins conspicuously darkened; distal segments of abdomen dark brown, much darker than the basal segments; male hypopygium with the caudal margin of tergite bilobed; apex of outer dististyle bidentate; gonapophyses and lateral arms of phallosome simple.

Male.—Length, about 4 to 5.5 millimeters; wing, 4.5 to 6.2.

Female.—Length, about 5 to 6.5 millimeters; wing, 5.5 to 7.

Rostrum pale brown; palpi brownish black. Antennæ brown throughout; flagellar segments oval, the verticils shorter than the segments. Head obscure yellow.

Mesonotum obscure yellow, the præscutum with four brownish gray stripes, the intermediate pair contiguous to nearly confluent, ending some distance before the suture; scutum yellow, the lobes darkened by caudal extensions of the lateral præscutal stripes; scutellum dark, with a small median yellow triangle at base; postnotal mediotergite dark, the cephalic-lateral angles paler; pleurotergite pale yellow, the ventral margin dark brown. Pleura yellow, variegated with brown, this color including the ventral anepisternum and the more extensive ventral sternopleurite. Halteres pale, the knobs light yellow. Legs with the fore coxæ infuscated, the remaining coxæ and all trochanters pale yellow; remainder of legs yellow, the outer tarsal segments brownish black; claws each with a basal spine. Wings (Plate 1, fig. 12) white; stigma brown, elongate-oval, the costal margin adjoining stigma more yellowish; longitudinal veins, with the exception of M and basal half of 1st A, narrowly seamed with brown, the veins being darkened, pale in the ground areas. Venation: Sc_1 ending a short distance before end of Rs; R_2 and r-m in nearly transverse alignment; cell 1st M_2 long, equal to the longest vein beyond it; m-cu at or only a short distance before fork of M.

Male with the abdominal tergites pale brown, with a capillary darker median line; segments 6 to 9, including hypopygium, more uniformly dark brown; female with abdomen more uniformly pale, the segments variegated with brown, the caudal margins narrowly yellow; terminal segments, including ovipositor, darker brown to brownish black. Male hypopygium (Plate 3, fig. 43) with the tergite, *9t*, transverse, the broad median portion produced, at the lateral ends of this area with a small obtuse tubercle; caudal margin of tergite incised medially. Outer dististyle, *od*, flattened, black, the apex unequally bifid. Gonapophyses, *g*, appearing as slender, simple rods, the tips very narrow, acute. Phallosome, *p*, with the lateral arms appearing as flattened blades, the two taken together appearing sublyriform.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, August 17, 1931 (*Franck*). Allotopotype, female, August 16, 1931. Paratopotypes, 3 males, 4 females, August 16 and 17, 1931.

Antocha (*Antocha*) *bidens* is very distinct from all regional species of the genus. The handsomely variegated wings, in conjunction with certain details of the male hypopygium, as the bituberculate ninth tergite and notched outer dististyle, furnish characters that are distinctive.

HEXATOMINI

ADELPHOMYIA LATISSIMA sp. nov. Plate 1, fig. 13; Plate 3, fig. 44.

General coloration of mesonotal præscutum bright brown, the posterior sclerites of the mesonotum darker brown; antennæ black throughout; legs brownish yellow; wings (male) broad, widest opposite the termination of vein 2d A; macrotrichia of cells very sparse, restricted to about eight in extreme outer ends of cells R_4 and R_5; abdominal tergites dark brown, hypopygium yellow.

Male.—Length, about 4.5 millimeters; wing, 5.5 by 1.8.

Rostrum and palpi brownish black. Antennæ black throughout; basal flagellar segments long-oval, the outer segments more elongate, the verticils exceeding the segments; terminal segment a little longer than the penultimate. Head dark brown; anterior vertex broad.

Pronotum dark brown. Mesonotal præscutum bright brown, the posterior sclerites of notum darker brown to brownish black. Pleura yellowish brown on ventral sclerites, darker brown dorsally. Halteres weakly infuscated, the base of stem narrowly yellow. Legs with the fore coxæ brownish yellow, the remaining coxæ more testaceous-yellow; trochanters yellow; remainder of legs pale brownish yellow; tibial spurs distinct. Wings (Plate 1, fig. 13) with a pale brownish tinge, the prearcular and costal regions somewhat more brownish yellow; stigma slightly darker brown than the ground; veins pale brown. Wings (male) wide, broadest opposite termination of vein 2d A; macrotrichia of cells restricted to about five in outer end of cell R_4 and about three in outer end of cell R_5; macrotrichia on veins beyond cord, basad of cord being found on R_1, outer three-fourths of Rs, outer portion of M and basal section of Cu_1, distal half of 1st A, but virtually lacking on 2d A. Venation: Sc_1 ending opposite fork of Rs, Sc_2 some distance from its tip, Sc_1 alone being nearly as long as m-cu; Rs weakly angulated at origin; R_2 a little longer than R_{2+3}; r-m long, gently arcuated; cell M_1 small; m-cu before midlength of cell 1st M_2; vein 2d A long.

Abdominal tergites dark brown, the sternites a little paler; hypopygium obscure yellow. Male hypopygium (Plate 3, fig. 44) with the outer face of basistyle, *b*, provided with very long, coarse, black setæ, the longest exceeding one-half the length of style. Outer dististyle, *od*, with two apical teeth, the outermost a little slenderer.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, August 17, 1931 (*Franck*). Paratopotype, male.

Adelphomyia latissima is most nearly allied to *A. flavescens* (Brunetti) (syn., *furcata* Brunetti) of the eastern Himalayas, differing most evidently in the broad wings of the male and the details of coloration, especially of the antennæ, thorax, and halteres. Both species have the macrotrichia of the wing cells so reduced in number as to indicate the probability of their total disappearance in some still undiscovered species of the genus. The structure of the male hypopygium in this genus is rather distinctive and should suffice to correctly assign any species with the cell macrotrichia greatly reduced or lost.

PHYLLOLABIS PICTIVENA sp. nov. Plate 1, fig. 14.

General coloration black; knobs of halteres infuscated; wings yellow, with most of the longitudinal veins broadly and conspicuously seamed with brown; R_{2+3+4} only gently arcuated; m-cu at about two-thirds the lower face of cell 1st M_2.

Female.—Length, about 7 millimeters; wing, 7.6.

Rostrum and palpi black. Antennæ with the scape black, the pedicel light brown; flagellum dark brown; flagellar segments elongate-oval, the verticils a little shorter than the segments. Head brownish black.

Pronotum, mesonotum, and pleura black. Halteres obscure yellow, the knobs infuscated. Legs with the coxæ brownish black; trochanters light brown; femora black; tibiæ brown, the tips narrowly infuscated; tarsi passing to dark brown. Wings (Plate 1, fig. 14) with a yellow tinge; stigma long-oval, dark brown; conspicuous brown seams on certain of the longitudinal veins, as follows: A very broad seam along vein Cu and the cord; somewhat narrower seams along Rs and all outer branches of the radial and medial fields; vein 2d A narrowly bordered by brown; wing margin and axillary border narrowly infuscated; veins brown, somewhat darker in the clouded areas. Macrotrichia of veins abundant but not of excessive length, occurring on all longitudinal veins excepting the basal sixth of M. Venation: Sc_1 ending about opposite one-third the length of Rs, Sc_2 a short distance from its tip; R_{2+3+4} only gently arcuated; m-cu at about two-thirds the lower face of cell 1st M_2; anterior arculus lacking or represented only by a weak clouding.

Abdomen black; cerci deep horn-color, long, nearly straight, their margins smooth; hypovalvæ pale yellow.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 11,000 feet, July 18, 1931 (*Franck*).

Phyllolabis pictivena is very different from the two other described species in the eastern Palæarctic region, *P. beesoni* Alexander and *P. confluenta* Alexander, both of the western Himalayas, in the intense black coloration of the body and in the handsomely patterned wings.

ERIOPTERINI

RHABDOMASTIX (PALÆOGONOMYIA) OMEINA sp. nov. Plate 1, fig. 15.

General coloration brown; antennæ (male) elongate, about two-thirds the length of wing; legs brown, the tarsi whitish; wings with a strong brown tinge; macrotrichia of veins very much reduced in number; Sc_1 ending at near midlength of Rs.

Male.—Wing, 3.5 millimeters; antenna, about 2.5.

Rostrum and palpi dark. Antennæ relatively long, being approximately two-thirds the length of wing, dark brown; flagellar segments long-cylindrical, with abundant erect setæ scattered over the whole surface. Head brown.

Mesonotum and pleura pale brown. Halteres broken. Legs with the coxæ and trochanters testaceous-yellow; a single leg (hind) remains; femora brown; tibiæ brown, somewhat paler apically; tarsi whitish. Wings (Plate 1, fig. 15) with a strong brownish tinge, the stigma not indicated; veins slightly darker brown. Macrotrichia of veins, excluding costa, very sparse and restricted, being confined to R_1 beyond cord, distal half of outer section of R_5 and outer portions of distal sections of M_{1+2} and M_3. Wings strongly narrowed basally, the anal angle greatly reduced. Venation: Sc_1 ending about opposite mid-length of Rs, Sc_2 at near mid-distance between origin of Rs and tip of Sc_1; Rs about one-half longer than R_{2+3+4}; space on costa between R_{1+2} and R_3 longer than the latter vein.

Abdomen broken.

Habitat.—China (Szechwan).

Holotype, a broken male, Mount Omei, altitude 4,000 feet, July 4, 1931 (*Franck*).

I am referring the present fly to the subgenus *Palæogonomyia* Meunier,[2] which has hitherto been known only as fossil in Baltic amber (Lower Oligocene). However, the distinctions between the three proposed subgenera, *Rhabdomastix* Skuse, *Palæogonomyia*, and *Sacandaga* Alexander, are so slight that the value of the present reference from a distributional standpoint must be held as being doubtful. It seems certain that the present species is more closely allied to the fossil species placed in *Palæogonomyia* than it is to any other described recent member of the genus. *Palæogonomyia* has the antennæ of the male elongate but still shorter than the wing, whereas the organ is very much longer in the typical subgenus while being very short in both sexes in *Sacandaga.*

GNOPHOMYIA COLLATA sp. nov. Plate 1, fig. 16.

General coloration of mesonotum black; head dark gray; halteres pale, the knobs dark brown; femora brownish yellow, the tips more infuscated; wings with a pale brownish tinge; macrotrichia of basal costal fringe very long and conspicuous; m-cu about one-half its length beyond fork of M; genital shield and cerci dark brown.

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[2] Meunier, F., Bull. Soc. Ent. France for 1899 (1899) 359; Ann. des sciences natur., Zoöl. IX 4 (1906) 372.—Alexander, C. P., Bernstein-Forschungen Heft 2 (1931) 111–117.

Female.—Length, about 7.5 millimeters; wing, 7.

Rostrum and palpi brownish black. Antennæ with the scape and pedicel dark brown, the flagellum black; flagellar segments long-oval to subfusiform, the longest verticils a little exceeding the segments. Head dark gray.

Pronotum and mesonotum black, the anterior lateral pretergites narrowly light yellow. Pleura with the dorsal sclerites black, the meral region much paler, obscure yellow. Halteres pale, the knobs dark brown. Legs with the fore coxæ dark brown, the middle and posterior coxæ yellow; trochanters brownish yellow; femora and tibiæ brownish yellow, the tips more infuscated; tarsi brownish black. Wings (Plate 1, fig. 16) uniformly tinged with pale brown; veins and macrotrichia dark brown; a very conspicuous obliterative streak crosses the basal sections of M_{1+2} and M_3 at both ends of cell 1st M_2. Macrotrichia of costal fringe very long on basal third of wing, becoming shorter and denser on outer portion of costa. Venation: Sc_1 ending just before fork of R_{2+3+4}, Sc_2 shortly beyond r-m; R_{2+3} exceeding two times R_2 alone; r-m connecting with Rs some distance before the fork; cell 1st M_2 small, its proximal end lying distad of that of cell R_5; cell 2d M_2 fully three times as long as cell 1st M_2; m-cu about one-half its length beyond the fork of M.

Abdominal tergites dark brown, the sternites pale yellow. Ovipositor with the genital shield and cerci dark brown.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 4,000 feet, August 14, 1931 (*Franck*).

The closest ally of the present species is *G. brevicellula* Alexander (Formosa), which is most readily told by slight differences in the coloration of the body, halteres, legs, and wings, and the details of venation. Both species have r-m connecting with Rs some distance before its fork and with cell 2d M_2 fully three times as long as cell 1st M_2. *Gnophomyia brevicellula* has a very remarkable hypopygium, and it will be of great interest to discover the male of the present species for comparison.

DASYMALLOMYIA PERSIGNATA sp. nov. Plate 1, fig. 17; Plate 3, fig. 45.

Mesonotal præscutum yellow, variegated with shiny black and chestnut areas; wings light yellow, with incomplete crossbands at level of origin of Rs and along cord; a cloud at fork of M_{2+3}; vein R_3 nearly one-half of R_4; male hypopygium with the outer dististyle bearing a median rounded tubercle that is set with coarse setæ.

Male.—Length, about 5 to 5.5 millimeters; wing, 5.3 to 5.5.

Female.—Length, about 6 millimeters; wing, 6.1.

Rostrum brown; palpi black. Antennæ bicolorous, the segments black, the incisures narrowly obscure yellow; flagellar segments oval, becoming more elongate outwardly, the verticils long and conspicuous, exceeding the segments. Head brown.

Mesonotal præscutum polished light yellow, handsomely patterned with black and chestnut, the sublateral areas being two black crossbars alternating with chestnut; median black stripe bordered centrally with chestnut; scutum yellow medially, the lobes polished black; scutellum infuscated, obscure yellow behind; postnotum brownish black. Pluera light yellow, variegated with large black areas. Halteres light yellow, the knobs broken. Legs with the coxæ brown; trochanters obscure yellow; femora yellow, with a narrow black subterminal ring; tibiæ yellow, narrowly tipped with black; tarsi yellow, the outer segments brownish black; legs conspicuously hairy. Wings (Plate 1, fig. 17) light yellow, the prearcular and costal regions somewhat deeper yellow; a sparse brown pattern, including a narrow, darker brown seam that extends from the stigma along the cord; a broader but paler crossband extending from the origin of Rs across the wing to the outer end of vein 2d A, vaguely and narrowly interrupted in cell M; a dark cloud at fork of M_{2+3}; veins yellow, darker in the clouded areas. Venation: R_{3+4} present as a distinct element, subequal to or longer than R_2; R_3 almost one-half the length of R_4.

Basal abdominal tergites black, the intermediate segments obscure yellow, the lateral margins broadly blackened; subterminal segments more uniformly darkened; hypopygium yellow. Male hypopygium (Plate 3, fig. 45) with the outer dististyle, *od*, having a slender, outer, curved spine and a more-elongate, stouter, inner arm, the median lobe with coarse setæ but without a spine, as in *signata;* inner dististyle a flattened pale blade, somewhat stouter than in *signata.*

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 27, 1931 (*Franck*). Allotype, female, altitude 9,000 feet, July 20, 1931. Paratype, male, with the allotype.

The only other described *Dasymallomyia* is the genotype, *D. signata* Brunetti, which has a wide range in the eastern Palæarctic region, from the eastern Himalayas, through western China, to Formosa. It has been taken on Mount Omei but at lower altitudes than the present fly. *Dasymallomyia persignata* is most readily told from *signata* by the basal dark crossband of the wings, the dark cloud at fork of M_{2+3}, the longer vein R_3, and the slight distinctions in the male hypopygium.

ERIOPTERA (ILISIA) MEGAURA sp. nov. Plate 1, fig. 18; Plate 3, fig. 46.

General coloration gray, the præscutum with four darker plumbeous stripes; antennæ and legs black; knobs of halteres light yellow; wings obscure whitish, the base more yellow; veins black, coarse; anal veins gently diverging; male hypopygium large and powerful, the tergite extensive; outer dististyle a slender rod; inner style a powerful two-armed structure.

Male.—Length, about 5.5 millimeters; wing, 5.8 to 6.

Rostrum and palpi black. Antennæ black throughout; basal flagellar segments short-oval, the outer segments becoming slenderer and slightly more elongate outwardly; terminal segment shortest; verticils not or scarcely exceeding the segments in length. Head light gray; anterior vertex broad.

Mesonotum gray, the præscutum with four darker plumbeous stripes, the intermediate pair confluent in front of the level of the pseudosutural foveæ, the latter blackened; no brightening of the pretergal region. Pleura dark gray. Halteres with the stem slightly infuscated, the knobs light yellow. Legs with the coxæ gray; remainder of legs black. Wings (Plate 1, fig. 18) with the ground color obscure whitish, the anterior prearcular region and basal portions of the costal region more yellowish; stigma small, brown; axillary region and vein Cu vaguely infumed; veins coarse, black. Venation: Sc_1 ending just before level of R_2; Sc faint, about opposite one-third the length of Rs; vein 2d A nearly straight, gradually diverging from 1st A.

Abdomen black, the caudal margins of the segments more grayish; hypopygium black. Male hypopygium (Plate 3, fig. 46) large and powerful, the tergite, 9*t*, extensive, arched. Outer dististyle, *od*, a slender, arcuated rod, its surface, except at extreme base, with microscopic appressed setulæ. Inner dististyle, *id*, large and bulky, the outer apical angle produced into a blunt blackened lobe, the inner angle extended into a compressed yellowish blade. Elements of the phallosome, *p*, forming flattened plates that are contiguous on the median line, the outer lateral angles produced into slender arms, the tips a trifle incurved, obtuse.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 9,000 feet, July 20, 1931 (*Franck*). Paratopotype, male.

The closest allied species is *Erioptera* (*Ilisia*) *bifurcata* Alexander (Japan), which has an almost identical appearance and venation but differs very notably in the structure of the male hypopygium, especially the elongate outer dististyle, the short, deeply furcate inner style, and the acicular gonapophyses. I consider that these two flies belong to *Ilisia*, where they are aberrant; they may be removed to some other group when allied forms are better known.

ERIOPTERA (TELENEURA) LEUCOPODA sp. nov. Plate 1, fig. 19.

General coloration of mesonotum dark brown; head and pronotum abruptly light yellow; antennæ black throughout; thoracic pleura brown, with a broad black longitudinal stripe; halteres brown; legs brown, the tarsi and tips of posterior tibiæ conspicuously whitened; wings broad, strongly infuscated; Rs fully one-half longer than R_{2+3+4}; abdomen black, the valves of the ovipositor abruptly horn yellow.

Female.—Length, about 4 millimeters; wing, 3.8.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, becoming more elongate-oval outwardly; verticils conspicuous, fully one-half longer than the segments. Head clear light yellow, contrasting abruptly with the mesothorax.

Pronotum yellow, the anterior lateral pretergites light sulphur yellow. Mesonotum dark brown, the humeral portion of the præscutum a trifle brightened. Pleura brown, with a broad black longitudinal stripe, extending from the propleura to the abdomen, passing beneath the root of the haltere; dorsopleural region brownish yellow. Halteres brown, the base of stem narrowly pale. Legs with the coxæ and trochanters brown; femora dark brown; tibiæ brownish black, the tips of the fore and middle tibiæ very narrowly paler, of the posterior tibiæ broadly and conspicuously whitened; tarsi white, the basitarsi of fore and middle legs more or less infuscated on more than basal half. Wings (Plate 1, fig. 19) broad, strongly tinged with brown; veins and macrotrichia darker. Marginal fringes and trichia of veins long and conspicuous. Venation: Rs relatively long, fully one-half longer than R_{2+3+4}; R_2 subequal to R_{2+3}; m-cu close to fork of M; vein 2d A very gently sinuous.

Abdomen black. Ovipositor with the basal shields blackened, the valves abruptly horn yellow; cerci strongly upcurved to the acute tips, their margins smooth.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 7,000 feet, July 27, 1931 (*Franck*).

Erioptera (*Teleneura*) *leucopoda* is readily told from the other described species of the subgenus by the clear yellow head and conspicuously whitened feet. By my key to the species of *Teleneura*[3] the fly runs to *E.* (*T.*) *melanotænia* Alexander (Philippines), which differs conspicuously in the smaller size, differently colored head, and darkened feet.

ERIOPTERA (TELENEURA) LUTEICLAVATA sp. nov. Plate 3, fig. 47.

General coloration of mesonotum medium brown, the pleura yellow with a narrow brownish black longitudinal stripe; head light yellow; knobs of halteres light yellow; legs black; wings with a strong brownish tinge; abdominal sternites and hypopygium yellow; male hypopygium with both dististyles slender, the inner acutely pointed; gonapophyses appearing as simple blackened hooks.

Male.—Length, about 3.4 millimeters; wing, 4.2.

Rostrum and palpi black. Antennæ with the scape and enlarged pedicel black; flagellum dark brown; flagellar segments becoming slenderer and more attenuate outwardly; verticils long and conspicuous, much exceeding the segments. Head light yellow; vertex broad.

Pronotum yellow. Mesonotum medium brown; the anterior part of præscutum a little darker, the lateral præscutal margins testaceous-yellow. Pleura yellow, with a narrow but conspicuous brownish black longitudinal stripe extending from the fore coxæ caudad, passing just beneath the root of halteres; ventral sternopleurite infuscated. Halteres pale, the knobs, including the setæ, light yellow. Legs with the fore coxæ black, the remaining coxæ and all trochanters obscure yellow; femora and tibiæ black (a single leg, middle, remains, broken beyond tibia); no indication of brightening at apex of tibia, as in *leucopoda.* Wings broad, with a strong brown tinge, the prearcular and costal regions somewhat more yellowish; stigmal area slightly infuscated; veins pale, the macrotrichia somewhat darker. Venation: Vein 2d A gently sinuous, ending opposite m-cu.

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[3] Philip. Journ. Sci. **46** (1931) 287.

Abdominal tergites brown, the sternites obscure yellow; hypopygium light yellow. Male hypopygium (Plate 3, fig. 47) with the outer dististyle, *od,* slender, the distal third blackened, the apex flattened and with parallel striæ. Inner dististyle, *id,* a little longer, appearing as a slender pale rod, the tip acutely pointed. Gonapophyses, *g,* appearing as simple curved hooks, the tips blackened, acutely pointed. Apex of ædeagus, *a,* very strongly curved.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

Erioptera (*Teleneura*) *luteiclavata* is most closely allied to *E.* (*T.*) *leucopoda* sp nov., from the same locality. The pale coloration of the thorax and abdomen, the yellow knobs of the halteres, and the unbrightened tips of the tibiæ, all preclude any reference of the present fly to *leucopoda.* It is unfortunate that all tarsi of the type are broken and it is thus impossible to determine whether or not the feet are whitened in any degree.

ORMOSIA PRÆCISA sp. nov. Plate 1, fig. 20; Plate 3, fig. 48.

General coloration of mesonotal præscutum and scutum reddish brown, the posterior sclerites and the pleura darker plumbeous brown; knobs of halteres light yellow; femora black, tibiæ and tarsi pale yellow; wings with a brownish tinge, sparsely variegated with small pale brown spots and whitish discal areas; veins R_3 and R_4 not curved strongly cephalad at tips; vein 2d A strongly sinuous; male hypopygium with three gonapophyses on either side.

Male.—Length, about 4 millimeters; wing, 4.5.

Head broken.

Pronotum dark brown. Mesonotal præscutum and scutum reddish brown, the posterior sclerites of mesonotum darker plumbeous brown, sparsely pruinose; pseudosutural foveæ and tuberculate pits brownish black. Pleura almost uniform plumbeous brown. Halteres dusky, the knobs light yellow. Legs with the small coxæ plumbeous-brown; trochanters brownish yellow; femora black; tibiæ and tarsi pale yellow. Wings (Plate 1, fig. 20) with a brownish tinge, sparsely variegated with pale brown spots and clouds at cord, fork of M_{2+3} and as small marginal clouds at ends of longitudinal veins; stigma dark brown, with a somewhat more yellowish area beyond it; disk of wing before cord, in outer ends of basal cells, and beyond cord in medial field, more whitish; veins pale, darker in the clouded areas. Macrotrichia of cells abundant but pale. Venation: Sc_1 ending opposite R_2, Sc_2 about opposite midlength of Rs; R_2 just beyond fork of R_{3+4}, the latter veins not strongly curved cephalad at tips; m-cu just before fork of M; vein 2d A strongly sinuous.

Abdominal tergites dark brown, the sternites somewhat paler; hypopygium dark. Male hypopygium (Plate 3, fig. 48) with the outer dististyle, *od,* small, the surface of apical half with transverse rows of microscopic setæ. Inner dististyle, *id,* broad, the outer apical angle produced into a relatively slender lobe. Gonapophyses, *g,* appearing as three arms or branches on either side, these relatively slender, the stoutest and longest arm with about three subterminal teeth, its branch with a single small subterminal tooth.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

Ormosia præcisa is most nearly allied to a group of Japanese species, including *O. takahashii* Alexander, *O. takeuchii* Alexander, and *O. tokunagai* Alexander, differing especially in the structure of the gonapophyses of the male hypopygium.

MOLOPHILUS ARIEL sp. nov. Plate 1, fig. 21; Plate 3, fig. 49.

Belongs to the *gracilis* group and subgroup; general coloraration black, sparsely pruinose to give a leaden appearance; antennæ (male) short; halteres black; male hypopygium with a single dististyle, this appearing as a stout rod that divides at apex into about eight slender branches.

Male.—Length, about 3 millimeters; wing, 3.8.

Rostrum and palpi black. Antennæ (male) short, black throughout; flagellar segments long-oval, the verticils exceeding the segments. Head dark gray.

Mesonotum and pleura entirely black, sparsely pruinose, to give a dark leaden appearance. Halteres black, the stem variegated by sparse yellow setæ. Legs brownish black. Wings (Plate 1, fig. 21) relatively narrow, strongly suffused with blackish; veins and macrotrichia black. Costal fringe and trichia of veins long and conspicuous. Venation: Sc_1 ending about opposite R_2; R_2 about in transverse alignment with r-m; vein 2d A ending opposite m-cu.

Abdomen, including hypopygium, black. Male hypopygium (Plate 3, fig. 49) with only two lobes of basistyle, *b,* developed, the dorsal, *db,* relatively small and slender, with long coarse setæ distributed over its entire length; ventral lobe, *vb*, large, flattened, at apex further prolonged into a more glabrous outer lobe. A single dististyle, *d*, appearing as a stout rod that divides at apex into eight slender branches to produce a broomlike appearance, the most-basal branch shorter; at base of style a small fingerlike lobule that bears a few setæ. Ædeagus long, slender.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

The somewhat remarkable male hypopygium readily distinguishes this species from all others of the genus. *Molophilus albireo* Alexander (China) is very similar in its general appearance but has an entirely different genitalic structure.

MOLOPHILUS ANTARES sp. nov. Plate 1, fig. 22; Plate 3, fig. 50.

Belongs to the *gracilis* group and subgroup; mesonotal præscutum and scutum reddish brown, the posterior sclerites of notum and the pleura dark brown; legs and halteres dark brown; wings with a strong brown tinge; male hypopygium with the basistyle elongate, the apical lobes and dististyles relatively short when compared with the body of the style.

Male.—Length, about 3 millimeters; wing, 3.5.

Rostrum and palpi brownish black. Antennæ (male) short, brown throughout; flagellar segments cylindrical or nearly so, the verticils much longer than the segments. Head dark brown.

Mesonotal præscutum and scutum light reddish brown, the posterior sclerites of mesonotum and the pleura dark brown. Halteres infuscated, the base of stem restrictedly yellow. Legs with the coxæ and trochanters yellow; remainder of legs dark brown, the femoral bases restrictedly obscure yellow. Wings (Plate 1, fig. 22) with a strong brownish tinge, the prearcular and costal regions somewhat darker; veins pale, the darkest veins pale brown; macrotrichia dark brown. Venation: r_2 lying opposite or just beyond the level of r-m; vein 2d A relatively long and gently sinuous, ending shortly beyond m-cu.

Abdomen dark brown; hypopygium brownish yellow. Male hypopygium (Plate 3 fig. 50) with the basistyles, *b*, long and slender, the various apical lobes and the dististyles considerably shorter than the main body of the style; dorsal lobe of basistyle short, obtusely rounded at apex, the distal half without macrotrichia; ventral lobe, *vb*, short, with a dense group of coarse setæ at apex. Outer dististyle, *od*, irregular in outline, with an outer blackened beak and an inner arm that bears two slender points, one being an acute spine. Inner dististyle, *id,* long, bent at near midlength, the apex microscopically roughened. Ædeagus, *a,* long and straight.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

Molophilus antares is very different from the other regional species of the *gracilis* group in the structure of the male hypopygium, especially the great length of the basistyles in proportion to the apical lobes, and in the structure of the outer dististyle.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *db*, dorsal lobe of basistyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Tipula* (*Trichotipula*) *polytricha* sp. nov., venation.
2. *Tipula mutiloides* sp. nov., venation.
3. *Macgregoromyia szechwanensis* sp. nov., venation.
4. *Macgregoromyia celestia* sp. nov., venation.
5. *Limonia* (*Limonia*) *francki* sp. nov., venation.
6. *Limonia* (*Limonia*) *laticellula* sp. nov., venation.
7. *Limonia* (*Limonia*) *bicornigera* sp. nov., venation.
8. *Limonia* (*Dicranomyia*) *sublimis* sp. nov., venation.
9. *Helius* (*Helius*) *infirmus* sp. nov., venation.
10. *Antocha* (*Antocha*) *constricta* sp. nov., venation.
11. *Antocha* (*Antocha*) *nigribasis* sp. nov., venation.
12. *Antocha* (*Antocha*) *bidens* sp. nov., venation.
13. *Adelphomyia latissima* sp. nov., venation.
14. *Phyllolabis pictivena* sp. nov., venation.
15. *Rhabdomastix* (*Palæogonomyia*) *omeina* sp. nov., venation.
16. *Gnophomyia collata* sp. nov., venation.
17. *Dasymallomyia persignata* sp. nov., venation.
18. *Erioptera* (*Ilisia*) *megaura* sp. nov., venation.
19. *Erioptera* (*Teleneura*) *leucopoda* sp. nov., venation.
20. *Ormosia præcisa* sp. nov., venation.
21. *Molophilus ariel* sp. nov., venation.
22. *Molophilus antares* sp. nov., venation.

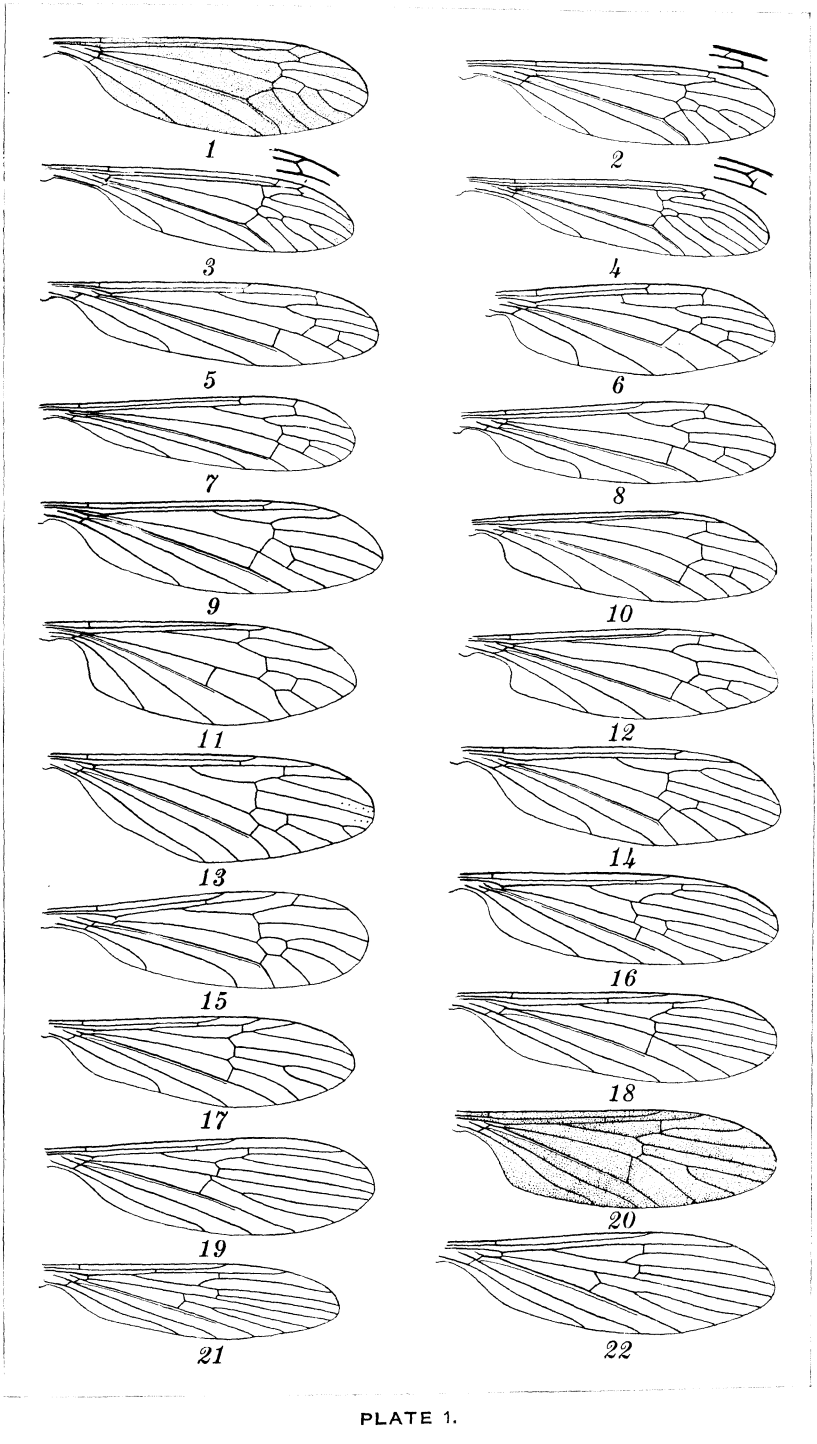
PLATE 2

FIG. 23. *Tipula* (*Trichotipula*) *polytricha* sp. nov., male hypopygium, lateral aspect.
24. *Tipula* (*Trichotipula*) *polytricha* sp. nov., male hypopygium, ninth tergite.
25. *Tipula* (*Trichotipula*) *polytricha* sp. nov., male hypopygium, ninth sternite.
26. *Tipula* (*Trichotipula*) *polytricha* sp. nov., male hypopygium, styli.
27. *Tipula mutiloides* sp. nov., male hypopygium, lateral aspect.
28. *Tipula mutiloides* sp. nov., male hypopygium, ninth tergite.
29. *Tipula mutiloides* sp. nov., male hypopygium, styli.
30. *Tipula mutiloides* sp. nov., male hypopygium, eighth sternite.
31. *Macgregoromyia szechwanensis* sp. nov., basal five flagellar segments, male.
32. *Macgregoromyia szechwanensis* sp. nov., male hypopygium, dorsal.
33. *Macgregoromyia celestia* sp. nov., basal five flagellar segments, male.

FIG. 34. *Macgregoromyia celestia* sp. nov., male hypopygium, inner dististyle.
35. *Limonia* (*Limonia*) *francki* sp. nov., male hypopygium.
36. *Limonia* (*Limonia*) *bicornigera* sp. nov., male hypopygium.
37. *Limonia* (*Dicranomyia*) *sublimis* sp. nov., male hypopygium.

PLATE 3

FIG. 38. *Helius* (*Helius*) *infirmus* sp. nov., male hypopygium.
39. *Antocha* (*Antocha*) *constricta* sp. nov., male hypopygium.
40. *Antocha* (*Antocha*) *multidentata* sp. nov., male hypopygium.
41. *Antocha* (*Antocha*) *spiralis* sp. nov., male hypopygium.
42. *Antocha* (*Antocha*) *nigribasis* sp. nov., male hypopygium.
43. *Antocha* (*Antocha*) *bidens* sp. nov., male hypopygium.
44. *Adelphomyia latissima* sp. nov., male hypopygium.
45. *Dasymallomyia persignata* sp. nov., male hypopygium.
46. *Erioptera* (*Ilisia*) *megaura* sp. nov., male hypopygium.
47. *Erioptera* (*Teleneura*) *luteiclavata* sp. nov., male hypopygium.
48. *Ormosia præcisa* sp. nov., male hypopygium.
49. *Molophilus ariel* sp. nov., male hypopygium.
50. *Molophilus antares* sp. nov., male hypopygium.



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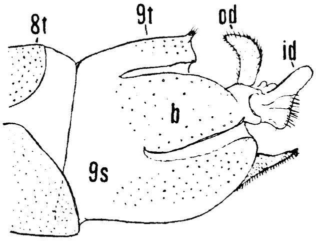

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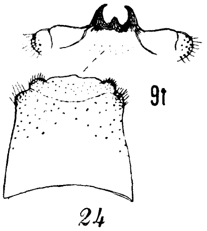

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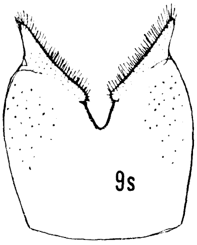

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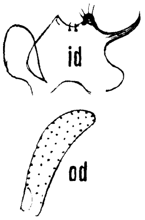

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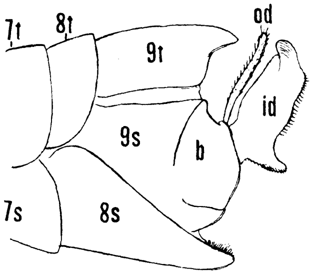

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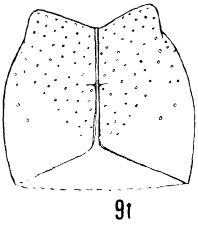

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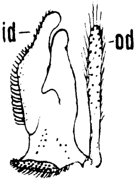

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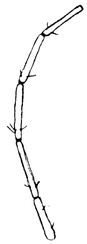

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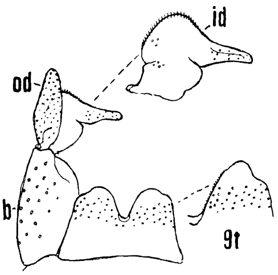

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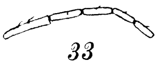

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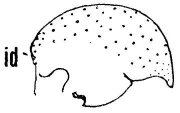

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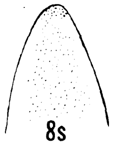
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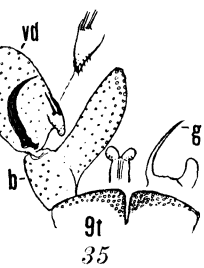

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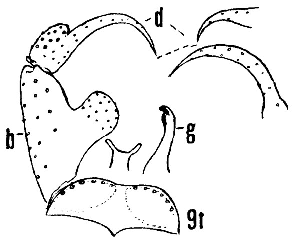

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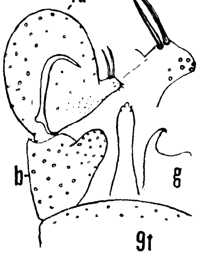

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PLATE 2.

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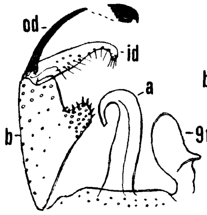

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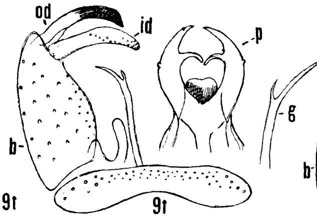

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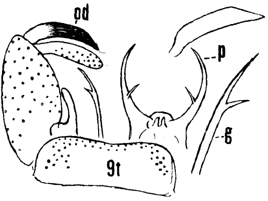

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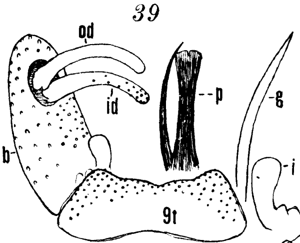

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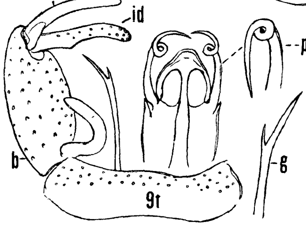

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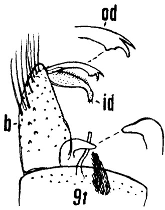

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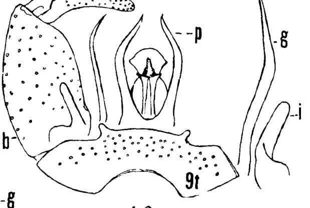

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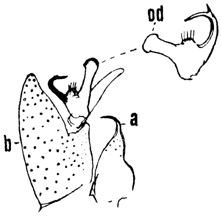

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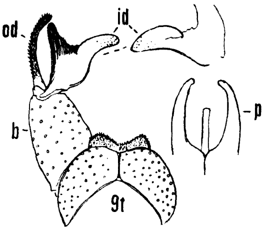

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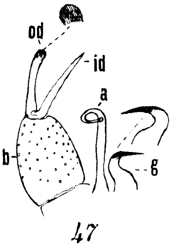

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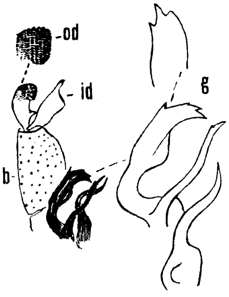

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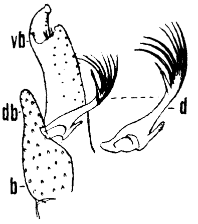

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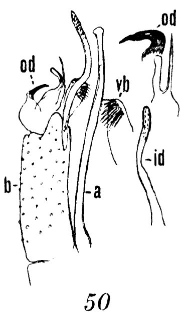

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PLATE 3.

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AN UNREPORTED FUNGOUS DISEASE OF THE PHILIPPINE MIGRATORY LOCUST[1]

By GAUDENCIO M. REYES

Of the Bureau of Science, Manila

FIVE PLATES

INTRODUCTION

Several parasitic fungi have been reported and described attacking insects, and in certain countries some of these fungi have been used with varying degrees of success in the control of destructive insect pests. Although these so-called entomogenous fungi help the farmer in his battles against economic insects, it would seem appropriate to cite the views of Charles,(6) as follows: "Although the results of studies have appeared from time to time, the subject (entomogenous fungi) as a whole has not been thoroughly investigated. That it offers much of purely scientific interest is unquestioned; what it still holds of potential economic value is yet to be discovered."

In the Philippines various fungi have been observed on a variety of insects, but little attempt has been made to study and describe them. In 1930, Celino(5) isolated a fungus from a dead coconut leaf-miner beetle, which was later identified by Dr. T. Petch(10) as *Beauveria bassiana* (Bals.) Vuill. Stevens,(15) in 1931, reported *Empusa grylli* (Fres.) Nowakowski on grasshoppers, *Cephalosporium crassum* Petch on *Pentalonia nigronervosa* Coq., and *Cordyceps podocreoides* von Höhnel on *Leucopholis irrorata* Chevrolat.

In September, 1929, at the Alabang locust laboratory and insectary of the former Bureau of Agriculture, a severe outbreak of a white fungus affecting the Philippine migratory locust, *Pachytylus migratorioides* Rch. and Frm. = *Locusta migratoria* ph. *migratorioides* Rch. and Frm.,(16) has attracted the writer's attention. The infestation was so serious that nearly all the stock of locusts was lost. Because of the seriousness of this fungous disease on the migratory locust, a study of it might prove valuable in the locust problem in the Philippines. As locusts were not available in the locality or elsewhere during the course of these studies, field experiments were abandoned. The present paper, therefore, only deals with the description of the disease and certain studies on the pathogenicity, morphology, behavior of the fungus in artificial media, and persistence of the fungus in culture.

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[1] Submitted for publication December 1, 1931. The writer wishes to express his deep appreciation to Mr. S. S. Gonzales, in charge of locust research of the Bureau of Plant Industry at Alabang, Rizal Province, for furnishing the materials for this work. Thanks are also due Dr. C. J. Humphrey, mycologist, and Dr. T. G. Fajardo, of the botany division, Bureau of Science, for the critical reading of the manuscript.

DESCRIPTION OF THE DISEASE

The early symptoms of the insect which becomes infected from artificial inoculation is the loss of appetite, apparent weakness and sluggishness, loss of the power of locomotion as if the muscles were paralyzed, and sooner or later death. The infected insect becomes somewhat darker than its normal color and upon dissection, fungous threads were found in the air cavities of the thorax (Plate 5), and in the thoracic and abdominal tissues. Tufts of mycelia can be seen coming out from certain parts of the body and spreading over the chitinous integument. The most striking external appearance of the disease, however, is the presence of cottony-white, floccose growth, protruding from the junctures of the body segments and the joints of the legs (Plate 5). Later these mycelial white masses sporulate heavily, and the color changes from white to ivory or creamy white. The insect afterwards becomes mummified (Plate 1, fig. 1) and the fungus can be seen practically covering the entire carcass.

THE CAUSAL FUNGUS

ISOLATION

The fungus was readily isolated by the spore dilution plate method (Plate 1, fig. 2). With this method a small amount of the fungus containing spores was first removed from fresh specimens and suspended in sterile distilled water. This suspension was further diluted by means of loop transfers into other tubes of sterile water. From the three dilutions, 1 to 3 loopfulls were transferred into tubes of melted potato glucose agar which had been cooled to 40° C., and vigorously shaken before they were poured into sterile Petri dishes. After two to three days incubation at room temperature, identical single spore colonies developing in the second and third plates of the series were isolated, preferably from the latter (Plate 1, fig. 2), and transferred into suitable media. The colonies obtained were essentially the same as the original material. All cultures used in subsequent studies of the fungus mentioned below were derived from single spore isolation.

PATHOGENICITY

Inoculations with the fungus obtained from single spore colonies proved beyond doubt the parasitic potentiality of the organism. In these experiments, healthy locusts reared from eggs were incarcerated in sterilized, relatively small wire cages and were supplied with abundant fresh, green grass planted in small beakers containing moist, sterilized sand. These were kept in the laboratory at temperatures ranging from 28° to 32° C. or over. The spores were applied on the insects either by spreading under the rudimentary wings or on the thoracic side, or by atomizing the insects direct on the leaves they ate with spores in sterile water suspension. For controls, the locusts were either left without treatment or sprayed with plain sterile water, depending on the method used.

The effect of infection was invariably fatal, death occurring after one to six days, the newly molted insects falling easy victims to the disease. The insects in the control remained still alive when examined after fifteen days. Reisolations proved positive. There was actually no substantial difference between the course of the disease in nature and in the laboratory.

The fungus readily attacks the locust in all its stages (Plate 5), causing from 60 to 100 per cent infection, and present results of carefully conducted experiments in October and November, 1929, seem to indicate that, as a rule, the younger the locust the more easily it succumbs, probably because the young are comparatively weaker, their cuticle being softer and thinner, and because of the comparative absence of wings or body protection. It was likewise found that those that molted immediately after the spores were applied usually escaped death. Following the suggestion of Howard,(9) it was further observed that the inoculations made in the afternoon gave better results, and a prolonged period of warm, humid weather favored the development of the fungus greatly. For lack of materials, no inoculation was attempted to infect egg pods.

In view of the fact that representatives of the genus *Beauveria* have been found to occur and infect different kinds of insects, trials were made to communicate artificially the locust fungus on the adult coconut leaf miners. In a series of tests conducted in large glass jars in the greenhouse and in relatively large wire cages in the open, its parasitic nature has been proven definitely on the coconut leaf-miner beetles, and the results obtained are printed in this issue.

MORPHOLOGY

The mycelium is septate, cottony-white, floccose, and branches out usually at right angles (Plate 3, fig. 3). The hyphæ are often connected by H-shaped unions or anastomosing branches (Plate 3, fig. 4). The mycelium is hyaline and granular when young, but later some may become somewhat vacuolated. In culture abundant conidia are produced from a sporiferous hymenial layer. A secondary crop of mycelia later appears on the surface from which a layer of conidia are again produced.

The conidia are minute, hyaline, smooth, single-celled (Plate 3, fig. 1), borne on slender flexuous sterigmata at the apex of each phialide (Plate 4, fig. 2). They are globose, rarely globoid (Plate 3, fig. 1, and Plate 4, fig. 3), having an average diameter of 2.17 microns, based on 100 measurements. Myriads of conidia are produced in loose globose heads either on the main hyphal branches or on short lateral ones. The conidia germinate readily in water, swelling overnight, and produce germ tubes which are constricted at the base (Plate 3, fig. 2). As the germ tubes grow, they in turn produce normal heads of globose conidia.

The conidiophores are short and simple and have a bottle- or flask-shaped "phialide" appearance. Each phialide bears one or sometimes two filiform, usually flexuous sterigmata (Plate 4) from which conidia are borne in a verticillate fashion. With the use of a filar ocular micrometer, the average diameter of the sterigmata is found to be 0.59 micron. The morphological features of the phialides, of the threadlike flexuous sterigmata, and of the successive production of globose conidia answer closely the essential characters of *Beauveria globulifera* or *Sporotrichum globuliferum* described by Dufrénoy(7) and Petch.(11)

BEHAVIOR OF THE FUNGUS ON DIFFERENT MEDIA

The fungus is readily cultivated on various media containing vegetable and animal substances. The type of colonies produced varied only slightly, but the density of growth and pigment production differed with the media used and with the age of the culture. Good growths were obtained from potato-dextrose agar, potato cylinders, steamed rice, cornmeal, cornmeal-beef agar and beef-malt agar, but a rather scanty growth was obtained on sterilized string beans, sterilized locust, sterilized coconut leaf-miner beetles, or on decoctions made from these insects. The following media were tested and the characteristic growths were noted.

Potato-dextrose agar.—The fungus grew on the surface bulging at the point of inoculation. Zonations were produced sloping rather indistinctly towards the margin of the colony. Later the white surface growth turned Ivory Yellow[2] and the zonation became barely conspicuous because of the formation of a sporogenous layer. As the medium dried up, a secondary, aërial, mycelial growth was produced, which later became inconspicuous by the subsequent formation of abundant spores (Plate 2, fig. 2). Through repeated subcultures the zonation became less distinct or entirely absent.

Potato cylinders.—A cottony-white, elevated, floccose growth (Plate 2, fig. 1) was obtained from this medium. A rather indistinct zonation of the colonies was observed. The medium turned Purplish Vinaceous, near the vicinity of the colonies corroborating the findings of Pettit,(12) and the fungus on the slant surface was Ivory Yellow. As the growth advanced, the pigment on the medium was obscured by the growth of mycelium, and the colonies became convoluted. A secondary growth of mycelium also took place and a few coremialike structures starting as small, buttonlike outgrowths on the surface have been observed. In subsequent cultures, however, these structures were hardly noticed.

Steamed rice.—The fungus grew rather luxuriantly on this medium, producing an abundant aërial, white, floccose growth (Plate 2, fig. 1), especially on steamed glutinous rice. On aging, the fungus became Ivory Yellow to Cream Color due to the formation of numerous conidia. A secondary mycelial growth was developed on different portions of the medium, occasionally clogging the tube. Later this gave rise to a few coremialike growths ranging from 9 to 11 millimeters in height, as the medium lost much of its moisture (Plate 2, fig. 2). In later subcultures, however, very few or none of these growths were formed. No color reaction was observed.

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[2] Capitalized color names are those of Ridgway's Color Standards and Color Nomenclature. Washington, D. C. (1912).

Cornmeal.—The fungus grew fairly well on cornmeal. As the growth thickened the fungus became tinged with Ivory Yellow and small scattered masses of cottony-white growth developed on the surface of the medium. The colony later became Cream Color with a faint purplish pigment produced in the immediate vicinity of the colonies.

Cornmeal-beef agar.—Growth was rapid, and the mycelium penetrated the substratum showing submerged development. Ivory Yellow color was produced on the sporiferous surface. A diffused Vinaceous Fawn color reaction took place in the substratum, which was not observed on other media.

Beef-malt agar.—Growth was very fast; the colony was dense, circular, and bulging aërially. In advanced stage of growth, zonations became somewhat distinct at the edge of the cultures. Ivory Yellow color appeared in the center of the colony as abundant spores were produced. No secondary crop of mycelium was noticed.

Potato agar.—The fungus growth was slow and scanty. Submerged growth of the mycelium was observed as in cornmeal-beef agar, but the conidia were produced on the surface, showing a somewhat powdery or chalky appearance. Later an Ivory Yellow tint was observed on the surface.

Sterilized string beans.—The fungus grew rather scantily but aërial mycelium was produced. The surface of the colony was white at first but later turned to Cartridge Buff as powdery masses of spores were produced. The beans were considerably consumed and became more or less transparent, leaving practically only the epidermal tissue.

From observations made of the growth characteristics of the fungus on the above-mentioned media, it is apparent that an elevated, cottony, floccose growth was distinctly and consistently shown on potato cylinders, steamed rice (glutinous or nonglutinous), potato-dextrose agar, and cornmeal, while a somewhat powdery or chalky type of growth was observed on cornmeal-beef agar, potato agar, beef-malt agar, and sterilized string beans.

IDENTITY AND SYNONYMY OF THE FUNGUS

The fungus under consideration appears to be identical in gross morphological and physiological characteristics with *Sporotrichum globuliferum* Speg. or *Beauveria globulifera* (Speg.) Pic., described by Saccardo,(13) Pettit,(12) Dufrénoy,(7) Petch,(11) and others. This fungus is characterized by the white, cottony, floccose growth. The conidia are globose, measuring on an average 2.17 μ, which approximates the recorded spore measurements of Spegazzini, as cited by Saccardo,(13) and Pettit.(12) For purposes of verification, cultures of the fungus and a photograph of infected locusts were sent to Dr. R. Thaxter, of Harvard University, who in a letter to the writer, dated July 20, 1930, states that he has no material for comparison, but "it seems exactly similar to the ubiquitous and more or less omnivorous *Beauveria globulifera*." The genus *Beauveria*, to which this species belongs, is an imperfect fungus of the tribe Verticillieæ. Various confusion in terminology has been made of representatives of the genus. Petch's treatise on *Beauveria*(11) states that the European writers have referred to members of this genus as *Botrytis* while the American mycologists placed them under *Sporotrichum* Link. In view of this confusion, the same author states that Vuillemin, in 1912, created a new generic name, *Beauveria*. As cited by Petch,(11) in 1914, Picard transferred Spegazzini's species, *Sporotrichum globuliferum*, to Vuillemin's genus as *Beauveria globulifera*. The writer, therefore, uses *Beauveria globulifera* for the parasite found on the Philippine migratory locust. Although the name *S. globuliferum* has been relegated to its synonymous binomial, *Beauveria globulifera*, some authors continue to refer to the fungus as originally described, and the names are used interchangeably.

DISTRIBUTION AND HOST RANGE

Among the entomogenous fungi, the genus *Sporotrichum*, or *Beauveria*, is known to be fairly widespread. According to Castellani,(4) the genus *Sporotrichum* has a large number of species found the world-over. Saccardo(13) and Petch,(11) citing the work of Spegazzini, stated that *Sporotrichum globuliferum* was found on Coleoptera, *Monocrepidium* sp., and *Naupactus xanthographus* in the Argentine, and subsequently on a *Gargaphia* (Hemiptera), also from the same country. Bruner(3) found *S. globuliferum* in 1897 in the Argentine and he, as well as Billings and Glenn,(2) and Headlee and McColloch,(8) found it parasitic on the chinch bug, *Blissus leucopterus* Say, in the United States. Bruner(3) and Headlee and McColloch(8) observed it on other insects. Bruner(3) further reported that a large migratory locust, *Schistocerca paranensis* Burm., was attacked by a species of *Sporotrichum*, the action of which is similar to that of *S. globuliferum* on the chinch bug. Howard,(9) in 1901, reported the successful infection of destructive grasshoppers in Colorado by a species of *Sporotrichum*. Petch(11) states that the parasitism of a given species of *Beauveria* is probably not restricted to one species of insect but to other groups of insects as well. Benois,(1) in 1928, reported the occurrence of five species of *Beauveria* on Acrididæ in European and Asiatic Russia. In 1929, Seymour(14) listed *S. globuliferum* as occurring on a wide variety of insects, including an acridid, *Melanoplus spretus* Uhl., and gave reference of its synonymy to *Beauveria globulifera* on certain species of *Cicada, Blissus,* and *Diabrotica.*

In the Philippines, the distribution of *B. globulifera* on the migratory locust is not definitely known, and as far as the writer is aware, no report of its occurrence on locust or other insect has been made.

VIABILITY OF THE FUNGUS

In series of experiments it was found that *B. globulifera* could persist in culture media under laboratory conditions and in the ice box for some time. Colonies kept at 28 to 32° C. for two hundred ninety-five days on steamed rice were still viable when transfers were made into fresh potato glucose agar. After four hundred forty days, colonies grown on steamed nonglutinous rice were already dead. The culture on sterilized locust was found dead at the end of two hundred twenty-five days. Colonies kept in potato dextrose agar, and steamed rice (nonglutinous and glutinous) at 13 to 15° C. were found viable at the end of two hundred ninety-five days. On glutinous rice cultures three hundred twenty days old, it was found still living. The summary of results is shown in Table 1.

TABLE 1.—*Viability of the fungus in culture media.*

Medium used as substrate.	Place of storage.	Temperature.	Age of culture.	Result.
		°*C.*	*Days.*	
Potato-dextrose agar	Room	28–32	225	Viable.
Do	do	28–32	295	Do.
Sterilized locust	do	28–32	225	Dead.
Steamed rice, glutinous	do	28–32	295	Viable.
Steamed rice, nonglutinous	do	28–32	295	Do.
Do	do	28–32	440	Dead.
Potato-dextrose agar	Ice box	13–15	225	Viable.
Do	do	13–15	295	Do.
Steamed rice, nonglutinous	do	13–15	295	Do.
Steamed rice, glutinous	do	13–15	295	Do.
Do	do	13–15	320	Do.

There are not enough comparative tests made of cultures kept in the two conditions, but it appears from the meager record obtained that the cultures kept in the ice box would live longer than those kept in the laboratory. Steamed glutinous rice seemed to have maintained the growth better and longer than the other kinds of media, probably because of its adhesiveness and capacity to retain moisture for a considerable period. These tests were not sufficiently extended or carried out on a large enough scale to warrant a definite conclusion, however.

SUMMARY

1. An entomogenous fungus attacking the Philippine migratory locust, *Pachytylus migratorioides* Rch. and Frm., is here reported for the first time in the Philippines.
2. The disease in an early stage can be readily recognized by the presence of white, cottony, floccose mycelial growths protruding from the junctures of body segments and joints of the legs, which in an advanced stage become sporiferous, the color changing to ivory or creamy white.
3. The fungus was isolated in pure culture and proved highly pathogenic on the Philippine migratory locust. The younger stages of the locust and those newly molted succumbed quicker than the adults.
4. The fungus has been cultivated on various artificial media containing a plant or an animal substance, or both, and spores were produced in enormous numbers.
5. The morphological and physiological characteristics of the fungus are identical with those of *Beauveria globulifera* (Speg.) Pic., formerly known as *Sporotrichum globuliferum* Speg., which attacks the chinch bug, *Blissus leucopterus* Say, in the United States. The fungus is characterized by having globose conidia and by the cottony-white, elevated, floccose growth in culture media.
6. On artificial media the fungus was still viable after two hundred ninety-five days at room temperature (28 to 32° C.), and in the ice box (13 to 15° C.) after three hundred twenty days. Steamed glutinous rice seemed to have maintained the growth better and longer than the other kinds of media used.

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ILLUSTRATIONS

[Photographs were made by G. Panlilio and V. Ferrer, of the Bureau of Science.]

PLATE 1

FIG. 1. Two mummified specimens of the Philippine migratory locust, *Pachytylus migratorioides* Rch. and Frm., practically covered with the white fungus *Beauveria globulifera* (Speg.) Pic., from which the culture was obtained. Note that the fungus is densely crowded over certain areas, as between segments of the body. About 1.2 times natural size.

2. Spore dilution of the fungus, 6 days old, on potato-dextrose agar + 1 F. S. Note the uniformity of the elevated, cottony, floccose mycelial growth of the colonies. × 1.

PLATE 2

FIG. 1. Cultures of *Beauveria globulifera* on two potato slants and two steamed-rice slants, 46 days old, showing aërial, cottony-white, floccose growths. About two-thirds natural size.

2. The tube to the left is a 3.5-month-old culture of the fungus on potato-dextrose agar slant, showing typical, raised, white growth of *B. globulifera*. The other two tubes in the middle and to the right, respectively, are drying cultures on potato cylinder and steamed rice, showing a few coremialike structures which are more visible in tube on the extreme right.

PLATE 3

[Camera-lucida drawings, × 1900.]

FIG. 1. A group of globose spores obtained from an old culture of the organism.

2. Germinating conidia kept overnight in water. Note the swelling of the conidia and constriction at the base of the germ tubes.

3. Hyphal threads showing septation and lateral branching.

4. Hyphæ showing considerable anastomosing.

PLATE 4

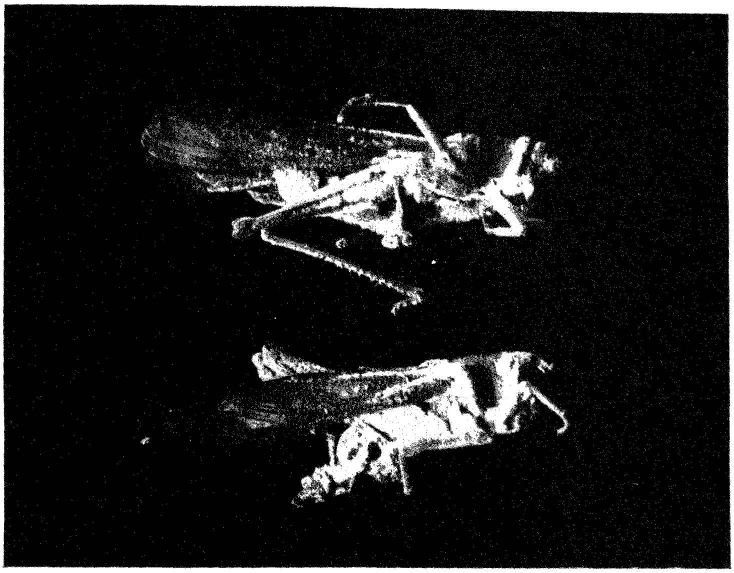
FIG. 1. Camera lucida drawings. *a*, Conidia abstricted singly from the apices of bottle-shaped, paired phialides. Note the end of the mycelial hypha budding an isolated conidium. Drawn from mounts obtained from 9-day-old colonies. × 1900. *b*, A camera lucida drawing, showing subsequent swelling of the phialides and the production of typical, slender, zigzag *Beauveria* sterigmata. Note that one of the phialides has two sterigmata. Drawn from 10-day-old colonies. × 1900.

FIG. 2. A vegetative hypha bearing flask-shaped phialides on the swollen phialidiferous part of the hypha. Note the conidia borne on short pedicels in a whorl-like arrangement, one below the other, on the flexuous sterigmata. Drawn with the aid of camera lucida. × 1900.

3. A photomicrograph of *Beauveria globulifera* showing zigzag sterigmata (about the center), dispersed spores, and a conidial head at the bottom (somewhat dimmed by a water bubble). × 900.

PLATE 5

Nymphs and adult Philippine migratory locusts artificially infected with *Beauveria globulifera*. Note the vigorous development of an identical fungus on the chitinous integument, emanating densely from the intersegmental membranes. Note also the fungous growths in the air cavities, and the invaded tissues in the thoracic and abdominal regions of the dissected adult insect.



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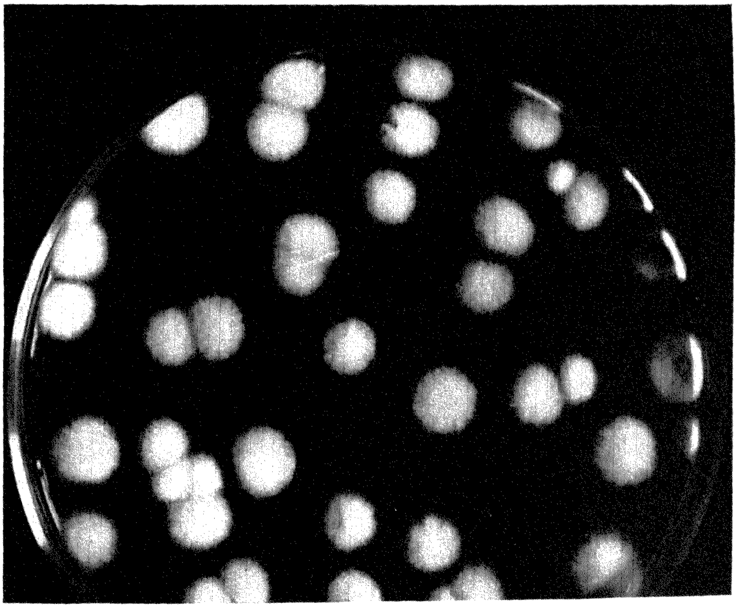

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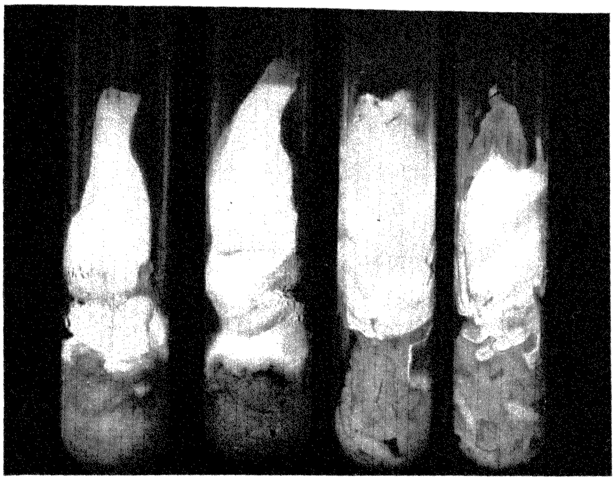

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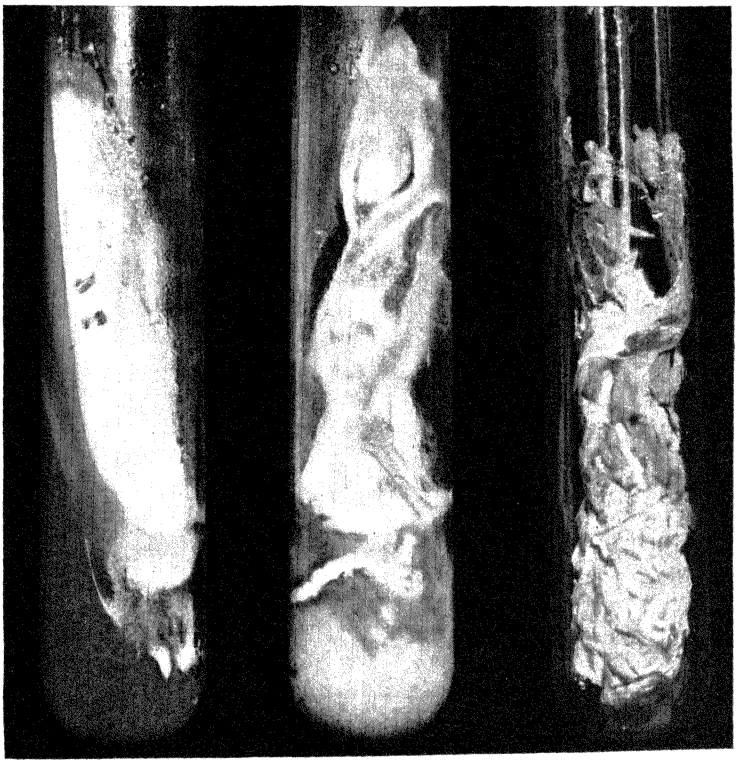

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PLATE 2.

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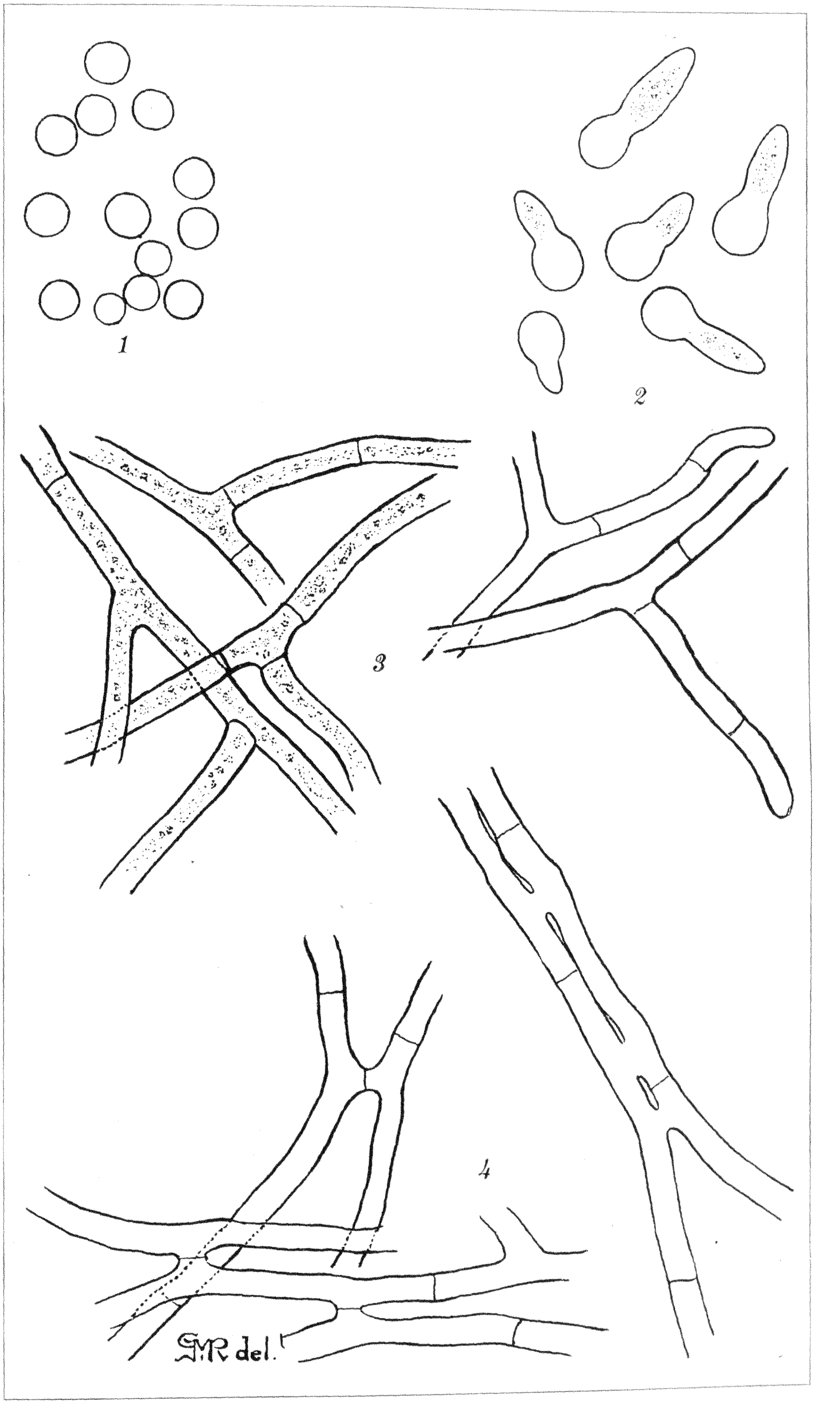

PLATE 3.

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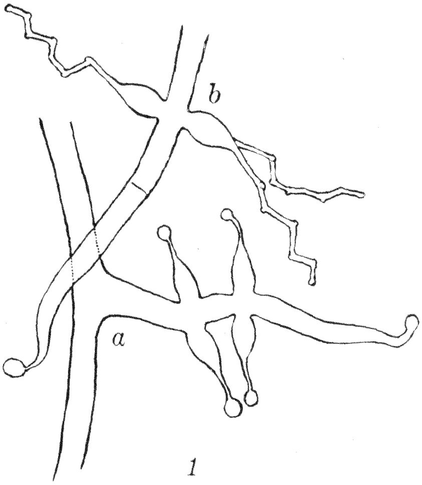

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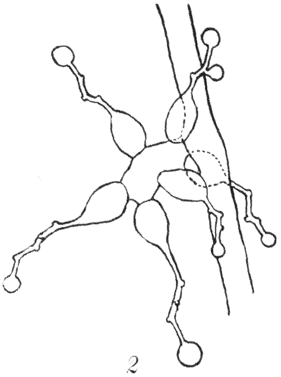

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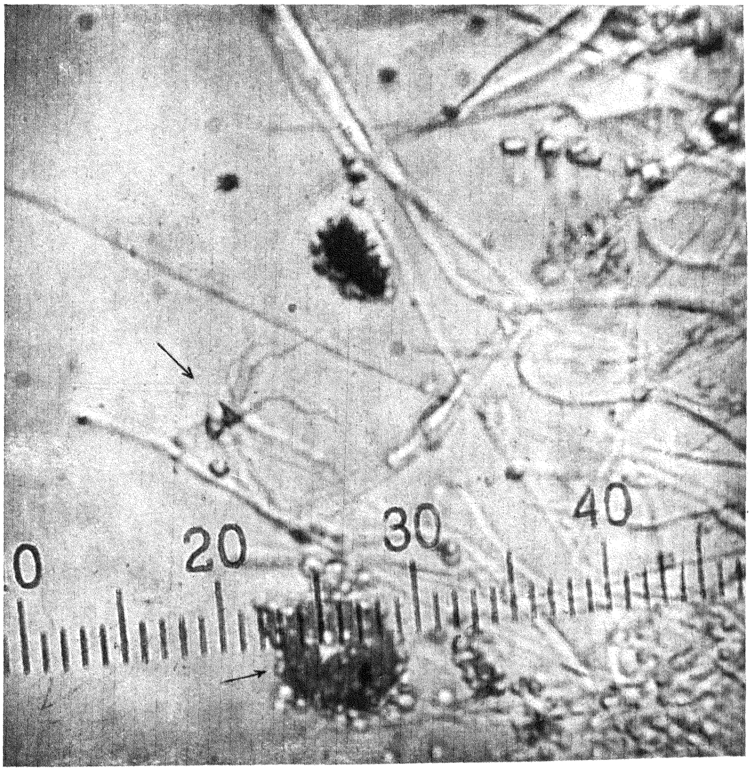

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PLATE 4.

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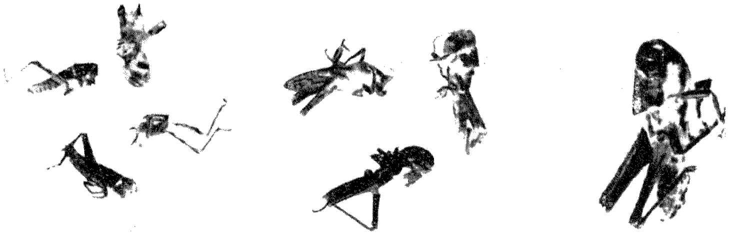

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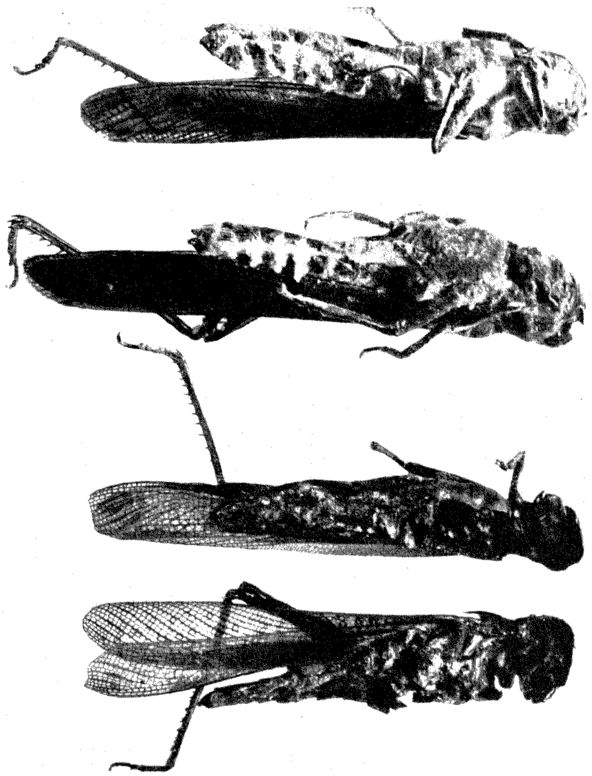

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PLATE 5.

UNIV. OF MICH.

ARTIFICIAL INFECTION OF THE COCONUT LEAF MINER WITH BEAUVERIA GLOBULIFERA (SPEGAZZINI) PICARD [1]

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FIVE PLATES

INTRODUCTION

The outbreak of an unusually heavy infestation of the coconut leaf miner, *Promecotheca cumingi* Baly,(19) in the Philippines in the latter part of 1929, afforded a splendid opportunity for investigations along biological lines. Six species of hymenopterous parasites have been discovered by entomologists of the Philippine Bureau of Plant Industry and these played a prominent rôle in the control of the coconut leaf miner.(1, 19) No less interesting perhaps are the fungous diseases that have been observed and cultivated. Celino has reported the occurrence of a fungus isolated from the coconut leaf-miner beetle,(5) which has been determined by Dr. T. Petch(15) as *Beauveria bassiana* (Bals.) Vuill.

The object of the present work was to study, by means of artificial cultures, the practicability of introducing the fungus *Beauveria globulifera* (Speg.) Pic., formerly known as *Sporotrichum globuliferum* Speg., isolated from the Philippine migratory locust, *Pachytylus migratorioides* Rch. and Frm.,(18) into the leaf-miner-infested regions. The writer's first efforts were directed toward determining the best method of dissemination. Unfortunately, on account of the limited time and facilities afforded, the writer had no opportunity to extend the investigation into the field on a large scale. However, certain significant features of value have finally been evolved, these being the results partly of outdoor experiments and observations.

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[1] Submitted for publication December 1, 1931. The writer wishes to express his gratefulness to Dr. T. G. Fajardo, of the division of botany, Bureau of Science, for certain suggestions and criticisms in the preparation of the manuscript, and to Dr. C. J. Humphrey, mycologist of the same bureau, for reading it.

DISTRIBUTION OF THE FUNGUS, OTHER HOSTS, AND ECONOMIC IMPORTANCE

As recorded in scattered literature, *Beauveria globulifera* occurs on various important insects in widely separated geographical regions. Available reports of the fungus show that it occurs definitely in the United States(4, 9) on the chinch bug, *Blissus leucopterus* Say, and, according to Headlee and McColloch,(9) on other insects of more or less economic importance. Dozier(7) found it on the larvæ of the codling moth, *Carpocapsa pomonella,* on apples in Delaware. Other reports of the fungus and the insects it attacks show that it also occurs in France,(3, 11, 12) in the Argentine,(17) and in the West Indies.(2, 14) There is little doubt of its occurrence in other foreign countries, especially in tropical and subtropical regions.

Authorities seem to disagree as to the efficacy or possibility of introducing or disseminating fungous parasites among insects; some think it utterly impracticable, while others believe it of considerable economic importance, at times exerting a great influence, while still others believe that the subject has not been thoroughly studied and its potential importance has not been unravelled as yet. For many years certain destructive insect pests have been fought more or less successfully by the artificial propagation and introduction of different kinds of entomogenous fungi and among these insect-destroying fungi *Sporotrichum globuliferum,* or *Beauveria globulifera,* plays an important part. In general, parasitic fungi help check the multiplication of injurious insects and help man in his struggles against these pests. Petch, cited by Martin,(13) states that the problem now confronting investigators of entomogenous fungi centers on how to be able to induce an epidemic upon insects at a time when an epidemic would not take place naturally.

As far as the writer is aware, *Beauveria globulifera* has not been reported as occurring on the coconut leaf miner, *Promecotheca cumingi* Baly, nor has there been an attempt to infect artificially this economic insect with this fungus. Celino,(5) however, has succeeded in artificially infecting adult coconut leaf miners with a closely allied fungus, which was later identified by Doctor Petch as *B. bassiana* (Bals.) Vuill.(15)

OBSERVATIONS ON THE INCIDENCE OF FUNGOUS PARASITES ON THE COCONUT LEAF MINER IN THE INFESTED AREAS

Contrary to the opinion or observations of previous investigators,(10, 13, 16) that when an insect pest has reached its maximum numbers or becomes excessively numerous a fungous epidemic generally ensues, did not hold true with the coconut leaf miner. As far as the author's observation is concerned, made during the months of March to October, 1930, and corroborated verbally by Messrs. F. Q. Otanes, S. S. Gonzales, P. Sison, entomologists, and other field personnel of the Bureau of Plant Industry, engaged in the leaf-miner eradication campaign in Laguna, Batangas, and Tayabas Provinces and other infested regions, there was no serious mycotic epidemic on the coconut leaf miner. The occurrence of a few isolated cases of inactive fungus pathogenes that the writer noticed in his trips to the coconut leaf-miner-infested localities, together with several specimens that came to the writer's attention through the courtesy of Mr. Gonzalo Merino, chief entomologist of the Bureau of Plant Industry and chief executive of the coconut leaf-miner eradication campaign, seems to indicate that the climatic and other environmental conditions then obtaining were unfavorable to their proper development. According to Petch,(16) the factors that govern the outbreak of fungous epidemics upon insects rest on a condition of the insects which renders them more liable to fungous attack. Charles(6) states that for their optimum growth and development they demand a high degree of moisture and temperature.

Judging from previous reports, therefore, together with the writer's personal experience, it would seem that the practical application of entomogenous fungi depends greatly on the circumstances obtaining in a particular place, such as the prevalence of the right weather and climatic conditions for the progress of the fungus, the relative numbers of the host insects, the gregarious habit of the insect, and withal the activity or virulence of the fungus. No less important are the methods and technic, such as the discovery of the most suitable media, use of the fungus in large doses, method of distribution and application, etc.

PARASITISM TESTS

ARTIFICIAL INFECTION OF THE COCONUT LEAF MINER UNDER GREENHOUSE CONDITIONS

Inspired by the belief that the locust fungus might be of some help in combating the coconut leaf miner, despite the apparent absence of natural outbreaks of fungous epidemics, the following experiments were undertaken. Its parasitism was therefore first proven in the greenhouse before attempting to use it in the open or in the natural habitat of the insects. If the disease were to be introduced into the field it was absolutely essential that one should know first if it would prove pathogenic to the eggs, larvæ, pupæ, or adult, to the host plant, or to the insect parasites of the coconut leaf miner. Also, one should find out beforehand the most feasible method of disseminating the fungus. In other words the main objectives in these experiments were to find out the infective capacity of the fungus on the coconut leaf miner, and to devise a suitable technic and method of spread for its practical application.

Experiment 1. Dusting coconut leaf-miner beetles with spores.—The first greenhouse [2] attempt to infect healthy beetles of the coconut leaf miner,[3] fresh from the coco groves in Tanawan, Batangas Province, was made January 22, 1930, at 3 p. m. Eighty-two beetles were placed in large, sterilized glass jars covered with sterilized, copper-wire gauze and were then dusted with spores dislodged from a fresh culture, seeing to it that all the insects came in contact with them. Eighty-two other beetles were subjected to the same conditions, without the application of spores, and used as control. Each jar was provided with food by inserting equal numbers of fresh green portions of coco-leaf pinnæ, their fresh-cut ends being submerged in sterile water contained in a small beaker to keep them as fresh as possible; the pinnæ were replaced daily by fresh ones. In order to preclude outside infection, the leaves, before cutting in pieces, were wiped with cotton moistened with mercuric bichloride solution (1 : 1000) and then washed with sterile water. To prevent marauding insects, such as ants, from gaining access to the jars, these were set in shallow pans containing a solution of Doctor Bode's bacillol.

The next morning the fungus spores were observed adhering to the body and elytra, but were more noticeable on the tarsi. The inoculated insects were more or less sluggish and not as active as those in the control jars. They seemed to have lost their desire to eat, and very few were actually seen on the leaves. The majority of the insects were found at the bottom of the jar in a weakened condition, and very few had the desire to escape through the wire-gauze cover. By comparison, the control insects were very active and the moment the wire gauze was removed they would crawl up quickly to the opening in an effort to fly away. Many were seen feeding on the leaves while some stayed at or near the mouth of the jars waiting for a chance to escape. The final results of the observations, showing the number of casualties in each jar, are given in Table 1.

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[2] This greenhouse has a glass roof and metallic-cloth sides so that there is a free circulation of air. At the time of the experiment there was very little sunlight admitted because of the branches of a large rain tree, *Samanea saman* (Jacq.) Merr., shading it.

[3] Obtained through the courtesy of Mr. J. M. Mendoza, associate mycologist of the Bureau of Science.

TABLE 1.—*Infection of adult coconut leaf miners by dusting with spores.*

Treatment.	Started.	Beetles.	Total mortality.			Beetles showing the fungus distinctly at the end of experiment.	Infection.
			Jan. 23.	Jan. 24.	Jan. 25.		
							Per cent.
Dusting	Jan. 22, 1930	82	21	67	73	46	[a] 63.0
Check	do	82	1	7	22	0	0.0

[a] Based on the total mortality observed January 25, 1930.

Seventy-three of the inoculated insects died in three days, while many of those in the control jar remained alive for a much longer period and the daily mortalities were much fewer. Disregarding the number of insects that presumably died of drowning, as they were found in the beaker of water supporting the coco-palm leaflets, and the few that were accidentally crushed or pinned between the glass jar and the wire-gauze cover, and as they showed no outward signs of infection, making a total of thirty-seven in the control lot and nine in the dusted, twenty-two died in the uninfected lot and seventy-three in the inoculated lot in three days. Due to the greater activity of the insects in the control lot, more insects died of drowning and by accident. Of the seventy-three individuals that died in the inoculated lot forty-six, or 63 per cent, showed distinct, identical fungous growths, which is considered here the actual number or percentage of infection. There seems, however, little doubt that more than forty-six beetles actually succumbed to infection, but because of mild attacks the outward manifestations of the fungus were more or less arrested by unfavorable environmental factors. Reisolations proved positive. No fungus appeared on the beetles that died in the control jar. Some of the control beetles survived until February 24, 1930, and eggs were found on the leaves after January 27, 1930.

The beetles collected from each jar were incubated individually in separate sterilized test tubes plugged with cotton. In about three days fungous growths were visible with the naked eye, coming out of the different parts of the carcass. With the aid of a hand lens these could be seen earlier.

The infected carcasses lose much of their lustrous appearance and become dull and darker brown ocher, while the controls retain their luster and much of their natural color (Plate 1). The fungous growths were more conspicuous ventrally than dorsally, and in some instances they covered much of the ventral surface (Plate 2). Generally the fungus came out more densely from the axillæ and at the juncture of the legs with the body segments. It was also visible at the joints of the legs, neck, the intersection of the segments, and at the extremeties (Plate 2). Occasionally the tarsi and the antennæ were attacked, but the elytra were seldom affected. The action of the fungus on the coconut leaf miner is more or less the same as on the locust.

The development of the fungus on the carcass was observed to be variable; on some the growth was luxuriant, on some moderate or fair, while on others it was scanty. This seems to indicate that weather conditions have a direct bearing on the behavior and growth of the organism. The differences might be ascribed also to the variation in the health or resistance of the individual insects.

Experiment 2. Spraying adult coconut leaf miner with spores in suspension.—In another set of experiments infection was carried out by spraying the beetles[4] with a spore suspension from a fine De Vilbiss atomizer. The sprayed beetles, numbering eighty-two, were kept in large glass jars and supplied with plenty of fresh portions of coco-palm pinnæ, following exactly the same procedure and technic as in the preceding experiment, except that the beaker of water supporting the coco-palm leaflets was covered with sterile cotton at the top to minimize the deaths due to drowning. The control beetles, also eighty-two in number, were atomized with sterile distilled water and kept under conditions similar to the inoculated ones. The bodies from both lots collected after each observation were kept singly in separate sterile test tubes plugged with cotton. The data given in Table 2 show the results of observation.

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[4] Furnished by Mr. Pedro Sison, of the Bureau of Plant Industry, and collected in Laguna Province.

TABLE 2.—*Infection of leaf-miner beetles by spraying with a spore suspension.*

Treatment.			Mortality. 1930.					Beetles showing the fungus distinctly at the end of experiment.	Infection.
Kind.	Started.	Beetles used.	Feb. 8.	Feb. 10.	Feb. 11.	Feb. 12.	Feb. 13.		
									Per cent.
Spraying	Feb. 7, 1930	82	4	31	60	70	71	52	[a] 73.2
Check	do	82	3	24	40	49	51	0	0.0

[a] Computed on the total mortality observed February 13, 1930.

From the above data it will be seen that the percentage of beetles visibly infected as a result of spraying is much higher than the percentage of infected beetles in the dusting experiment. Of a total of eighty-two beetles sprayed seventy-one were killed, but it took five days, of which fifty-two, or 73.2 per cent, showed a marked external growth of the inoculum on their carcasses. Eleven were either drowned or accidentally killed. Although most of the insects died, those that showed no trace of the fungus were considered uninfected or to have died a natural death. There is no concrete evidence to show that all those that died in the sprayed lot were killed by the fungus, and no attempt was made to dissect all the dead insects showing no fungus evidence, owing to their smallness and their tendency to break easily into fragments, or become dismembered, under slight pressure. Nevertheless, the few cases successfully dissected longitudinally showed fungous growths, which, when cultured, yielded a species of *Aspergillus*.

Fifty-one of the control insects died, but some lived for a longer time than those inoculated. No fungus was observed. Twenty-five of the beetles were either drowned or killed by accident and two escaped.

Owing to the close similarity of the growth of the fungus on the victims (Plate 3) only a few reisolations were made from the doubtful cases and these gave positive results. Spraying evidently proved more effective than dusting with spores, probably because the spores were provided with extra moisture, which facilitated germination and initial infection.

Experiment 3. Infection of healthy coconut leaf-miner beetles[5] *by contact with inoculated ones.*—In this experiment, which was conducted in duplicate, it was the aim to create a sort of epidemic or infect healthy living specimens by mixing with them a few inoculated ones. Ten active beetles were selected and smeared with a thick spore suspension of the fungus in a sugar solution and then released in a sterilized glass jar containing a certain number of disease-free beetles. The same procedure and aseptic precautions were followed as in the foregoing experiments, excepting the method of infection. All dead beetles from the four jars were removed and kept in separate sterile test tubes with cotton plugs for further examinations. The number of beetles used in these tests were not the same because of the extreme difficulty in counting large numbers, and in order to avoid unnecessary handling. The results are shown in Table 3.

TABLE 3.—*Showing the results of infecting healthy adult coconut leaf miners by introducing with them inoculated ones.*

Treatment.				Total mortality.				Beetles showing the fungus distinctly.	Infection.
Kind.	Started.	Beetles used.	Beetles inoculated.	Mar. 17.	Mar. 18.	Mar. 19.	Mar. 22.		
									Per cent.
Natural contact	Mar. 15, 1930	99	10	53	64	64	69	8	[a] 11.6
Control	do	95	0	39	44	44	46	0	0.0
Natural contact	do	104	10	49	62	65	68	5	[a] 7.3
Control	do	122	0	56	60	61	[b] 62	0	0.0

[a] Based on total mortality observed March 22, 1930.
[b] Two beetles were attacked by a species of *Aspergillus*.

The few cases of successful infection that resulted from the foregoing experiment proved this method to have no appreciable effect. In the first set only eight beetles developed the disease while in the second set only five were infected, indicating that probably no contamination took place, and not even the ten beetles introduced with the fungus in each set of experiment were all killed. This seems to show that with this particular insect pest, the possibility of artificial transmission or spread of the fungus by natural contact is very meager, if not altogether lacking. As far as the writer's observation is concerned, the only possible chance of contact is when a healthy beetle copulates with an infected one, or when a relatively large number of the insects are confined in cramped quarters, so that the live beetles pass over the dead remains. Wind may blow spores from infected insects and, by chance, some of such spores may lodge on uninfected beetles. The same fungus was recovered in reisolations.

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[5] Obtained through the courtesy of Mr. F. Q. Otanes, entomologist of the Bureau of Plant Industry, around San Pablo, Laguna Province.

ARTIFICIAL INFECTION OF THE COCONUT LEAF MINER IN LARGE WIRE CAGES PLACED IN THE OPEN

The results of infection experiments conducted in the laboratory have often been criticized because the conditions under which the insects were kept could not be called normal, and the methods evolved could not be applied in practice on a large scale. With this in mind, experiments were undertaken outdoors where fresh and usually drier air prevails, in order to simulate nature as much as possible and at the same time approach, as far as is humanly possible, an efficient method.

The larval and pupal stages of the coconut leaf miner are passed in excavations, made by the larvæ in the parenchyma of the leaves between the upper and lower epidermis, so that they are more or less protected from the attack of nonmotile organisms. The use of fungous parasites, therefore, is somewhat at a disadvantage in this respect.

Large wire-screen (1/16-inch mesh) cages, made for the purpose were used. The cages were 1.5 meters high, 90 centimeters wide, and 90 centimeters deep. The wooden frame-work consisted of narrow strips in order to secure normal aëration as far as possible (Plate 5). The legs were set in shallow vessels containing a solution of Dr. Bode's bacillol to prevent ants and other insectivorous animals from gaining entrance. After sterilizing the cages, two healthy and vigorous coco-palm seedlings, about 2.5 meters high, free from leaf-miner attack and other blemishes and planted in sterilized soil in pots, with the leaves having been previously sterilized, were set on the wooden floor of each cage (Plate 5). All the cages were placed in the open but were so arranged that they received no sunlight after 1 o'clock in the afternoon. In order to assure the use of almost sterile beetles, trips were made to the leaf-miner regions to secure new broods as much as possible, and some were bred by the writer in a large wire cage, where the stock of beetles were released and fed before using. For every experiment therefore a fresh supply of beetles was used, and these were collected from the coco-palm groves not treated with insecticides. All outdoor infections were done in the afternoon in order to maintain a certain amount of humidity about the experimental cages and to avoid rapid drying of the solution enveloping the microspores. Thus, the experiments were as nearly normal as possible.

Experiment 1.—In this infection experiment fifty healthy and active beetles [6] were selected for each of the two treatments and fifty for the control. Two methods of inoculation were employed: First, by dipping twenty beetles for a few seconds in a suspension of spores in syrup solution made by mixing copious spores in 1 cubic centimeter of 2:1 boiled syrup with 20 cubic centimeters of sterile distilled water, and then releasing them in cage 1 containing thirty healthy beetles supplied with abundant fresh food. Second, by spraying the lower surfaces of the sterilized leaves in cage 2 with a spore suspension until they were visibly wet before liberating inside fifty beetles, collected in a sterile test tube with the help of a curved, flexible forceps. The spores used for this experiment were obtained from a 42-day-old potato-glucose-agar culture. In the control cage, or cage 3, which was placed some distance away, the lower surfaces of the sterilized coco leaves were atomized with sterile water and twenty of the beetles were dipped in sterile water before releasing them with thirty others. The dead or dying beetles were collected individually in separate sterile test tubes provided with sterilized cotton plugs after each observation. The percentages of infection resulting from the two methods are presented in Table 4.

From Table 4 it will be seen that the chance of artificially propagating the fungus by natural contact is very meager, despite the proportion of beetle carriers to facilitate contacts. The result was not very encouraging as only two beetles were contaminated. This may be attributed partly to the fact that the insects do not wander en masse. It is believed, however, that if more beetles were used more would be proportionately infected. On the other hand, the spraying of the undersurfaces of the leaves proved more successful, causing 48 per cent infection. It was about a month before all the beetles in cages 1 and 2 died. As some of the beetles in the control cage lived for a longer time than in the treated cages, the experiment was concluded August 20, 1930, when three were still alive. In the

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[6] Obtained through the kindness of Mr. S. S. Gonzales, assistant entomologist of the Bureau of Plant Industry, from Lipa, Batangas Province.

TABLE 4.—*Result of artificial infection of adult coconut leaf miner by dipping in spore suspension in syrup solution, or spraying the lower surfaces of the coco leaves with spores diluted with sterile water.*

Set.	Cage No.	Beetles used.	Treatment.	Days observed.	Mortality.		Beetles showing fungous growths.	Infection.	Remarks.
					Beetles died.	Inclusive dates.			
								P. ct.	
July 1, 1930	1	50	Dipping 20 beetles in spore suspension before mixing with the others.	32	50	July 2 to August 2, 1930.	22	44.0	Six beetles pasted by the fungus on the leaves.
	2	50	Spraying the leaves before allowing beetles to eat.	30	50	July 5 to 31, 1930.	24	48.0	Nine beetles pasted by the fungus on the leaves and three on wire. One accidentally killed.
	3	50	Control; 20 beetles dipped in, and leaves sprayed with, sterile water.	50	47	July 19 to August 20, 1930.	None.	0.0	Three beetles still living August 20, 1930.

treated cages some of the beetles that perished without losing their hold on the leaves were held fast to the leaves by a copious growth of fungus on their bodies (Plate 4), and three were found held to the wire-screen wall of cage 2 by the fungus that covered them, although the majority dropped to the floor. The hypogenous attack on the leaves was much in evidence by the longitudinal scars present, and eggs were laid, especially on the leaves in the control cage. The insects that died as a result of infection were not readily recognized until they displayed conspicuous mycelial outgrowths from their body sutures. A similar diseased condition invariably developed in the infected beetles, while none of the untreated ones showed any evidence of fungus. Reisolations agreed in all respects with the culture used as inoculum.

From the result of the second part of the experiment, there seems to be no doubt that the spores in the leaf tissues ingested by the beetles live within and penetrate the insect tissues through the chitin integument, developing profusely on the surface. A more liberal use of the fungus would probably have more disastrous effects. Dufrénoy,(8) in his studies on the transmission of plant diseases through biological channels, found that some coleopterous insects harbor certain parasites in their alimentary canal, which multiply and remain during a part of their life cycle and cause infection when conditions become favorable. This author further states that in some instances the insect carriers become the victims of the fungi they carry, such as *Beauveria*.

Experiment 2.—Another method of infection has been tried in this experiment; that is, by spraying coconut leaf-miner beetles[7] while they were feeding on the leaves with spores suspended in sterile water, using a fine atomizer. The experiment was begun October 11, 1930, using spores obtained from a 30-day-old culture on leaf-miner decoction agar.[8] The beetles in the control cage were atomized with sterile water. All precautions used in the preceding experiment were observed carefully. The results are recorded in Table 5.

TABLE 5.—*Artificial infection of leaf-miner beetles by spraying them on the leaves they ate with a spore suspension.*

Cage No.	Date.	Beetles used.	Treatment.	Observations.		Beetles showing fungous growths.	Infection.	Remarks.
				Dates.	Total mortality.			
							P. ct.	
1	Oct. 11, 1930	50	Beetles sprayed on the leaves they eat with spore suspension.	Oct. 13 to 21, 1930.	43	29	[a]67.4	Four pasted by the fungus on the leaves.
3	Oct. 11, 1930	50	Control; sprayed with sterile water.	Oct. 18 to Nov. 25, 1930.	40	0	0	None.

[a] Based on total mortality.

Of the fifty beetles sprayed forty-three died. Twenty-nine of these showed the presence of the inoculum used, and four of them were found pasted by the fungus on the undersurfaces of the leaves. Taking into account only those that showed the presence of the fungus, the rate of infection by this method was 67.4 per cent, which, by comparison, is considerably higher than in the preceding experiments, conducted also under similar conditions, and the beetles succumbed much quicker. At the time this experiment was in progress, the Rev. Dr. Miguel Selga, director of the Weather Bureau, Manila, reported the prevalence of a prolonged warm, humid atmosphere,[9] which probably accounts, in part, for the high rate of mortality, which is also accentuated by the use of cultures of suitable virulence, and through exposure to both internal and external infection.

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[7] From a new brood of adult coconut leaf miner collected at Lumut, Calauan, Laguna Province.

[8] This medium is a mixture of 100 grams pounded leaf-miner beetles (oven-dried), 15 grams agar-agar, 20 grams dextrose, and 1,000 cubic centimeters distilled water.

When the experiment was closed seven beetles were still living in the sprayed lot and ten in the unsprayed. None of the control beetles that died showed any trace of fungous attack. The action on the beetles is similar to that on its usual host. The same fungus was recovered in reisolations.

The above experiments show evident results and will lead to more extensive experimentation, but results are far from being invariably successful because success is contingent upon certain ecological factors beyond human control.

EXPERIMENTS ON THE EFFECT OF THE FUNGUS ON THE PLANT HOST

In view of the fact that *Sporotrichum globuliferum* Speg.(9) and other species have been observed to infect plants, tests were conducted with a view to finding whether or not the fungus would also affect the coco palms. July 15, 1930, two young, healthy coco seedlings, about 2.5 meters high, were sprayed by means of an atomizer, on the foliage and at the base of the youngest leaf with a large dose of spores diluted in sterile water, to the extent of drenching the growing point. The same process was repeated July 22, 1930, or just a week later. Another plant used as control was sprayed with sterile water.

From July 29 to October 18, 1930, when the experiment was closed, observations made at weekly intervals revealed that the fungus had no ill effects on the coco seedlings. Spores sprayed on the leaves and on the growing point apparently produced no disease symptoms. It proves that if the fungus is used extensively to control the leaf miner, there should be no fear of the fungus damaging the coco plants except perhaps through mechanical injuries, or when the fungus is transported through wounds

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[9] Absence of typhoons now is cause of prevailing heat wave. The Tribune Year 6, No. 140 (1930) 12, Manila, Philippines.

TABLE 6.—*Observations on the effect of spores of Beauveria globulifera (Speg.) Pic. sprayed on coco-palm seedlings; sprayed July 15 and 22, 1930.*

Observations.[a]		
Date.	Seedling 1.	Seedling 2.
1930		
July 29	No effect	No effect.
August 5	do	Do.
August 12	do	Do.
August 19	do	Do.
August 26	do	Do.
September 2	do	Do.
September 9	do	Do.
September 16	do	Do.
September 23	do	Do.
September 30	do	Do.
October 7	do	Do.
October 14	do	Do.
October 18	do	Do.

[a] The control seedling remained healthy also.

or tunnels made by other insects, such as the red coconut weevil, *Rhynchophorus ferrugineus* Fabr., which has been declared by Petch(17) susceptible to the attack of either *Beauveria globulifera* or *B. bassiana* in specimens he obtained from Ceylon.

TESTS FOR LONGEVITY OF SPORES SPRAYED ON THE LOWER SURFACES OF COCO LEAVES

August 11, 1930, spores from a 20-day-old culture of *Beauveria globulifera* (Speg.) Pic. were mixed with 2 per cent syrup solution and 2 per cent gum arabic solution and sprayed separately on the lower surfaces of the leaves of two coco-palm seedlings. Before spraying, the leaves were wiped with cotton moistened with 1 : 1000 mercuric chloride and later washed thoroughly with cotton drenched with sterile water. At certain intervals spores adhering to the lower surfaces of the leaves were tested for viability, and at the close of the experiment the sprayed leaves were examined for symptoms that might have been caused by the fungus. The results are recorded in Table 7.

Table 7 shows that the viability lasted sixty-nine days on the leaves sprayed with spores diluted with 2 per cent syrup solution and a much shorter time on the leaves sprayed with spores mixed with 2 per cent gum arabic solution. Gum arabic and syrup were used not so much with the view to prolonging the life of

TABLE 7.—*Tests for the longevity of spores of Beauveria globulifera (Speg.) Pic. in suspension, sprayed on the lower surfaces of the coco-palm leaves.*

Plant No.	Vehicle used in spraying spores.	Culture.	
		Age.	Used.
1	Syrup (2 : 1) diluted with sterile water 2 per cent.	Twenty-day old on potato glucose agar+1 F. S.	Aug. 11, 1930.
2	Gum arabic, 2 per cent in sterile water.	----do----------------------	Do.

Plant No.	Date tested and observation.				Remarks.
	Aug. 19, 1930.	Sept. 11, 1930.	Sept. 25, 1930.	Oct. 18, 1930.	
1	Viable--------	Viable--------	Viable--------	Viable--------	No disease developed.
2	-----do-------	-----do------	None---------	None---------	Do.

the organism but mainly to serve as adhesives. The syrup solution in this experiment apparently served the dual purpose intended and gave the better result. A further test would probably show that the spores will remain viable for a much longer period, especially if they are applied more abundantly and spraying is done more liberally, so that a larger quantity of the spores stick to the leaves and facilitate detection. As the spores constitute the chief means of propagation, the significance of the test cannot be too strongly emphasized as on it will depend to a large measure the success of the agricultural application of fungous diseases against injurious insects destructive to, or feeding on, the leaves, under normal conditions or in their native habitat. This test again proved the harmlessness of the fungus to the plant host.

EFFECT OF THE FUNGUS ON THE HYMENOPTEROUS PARASITES OF THE COCONUT LEAF MINER

Of the natural enemies of the coconut leaf miner that played a prominent rôle there are six species of hymenopterous parasites, commonly called larval parasites, preying on the larvæ and pupæ.[10] To determine the susceptibility of these tiny insects to *Beauveria globulifera*, three experiments were conducted in the laboratory.

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[10] Information obtained from Mr. Pedro Sison, assistant entomologist of the Bureau of Plant Industry, March 13, 1930.

EXPERIMENT I

March 13, 1930, a few newly emerged larval parasites were obtained from Mr. Pedro Sison, assistant entomologist of the Bureau of Plant Industry at San Pablo, Laguna Province. Six of these tiny insects were confined in a sterilized 1-inch-diameter test tube plugged with cotton and were supplied with sugar-solution food placed on a piece of paper in small droplets. Four others were placed in another test tube of the same size and were given the same treatment. These tubes were placed horizontally on a table near a window. March 19, 1930, in the afternoon, six insects in one of the tubes were transferred into a sterile test tube, the inner wall of which was literally covered with a thin layer of spores of *Beauveria globulifera.* They were allowed to roam about for a few minutes until spores could be seen clinging to them, with the aid of a hand lens, when they were transferred again to the tube from whence they came. The other four insects in the other tube were used as controls. Great care was taken that none of the insects received injury of any kind in handling. The setting of the experiment was done expeditiously to avoid contamination from the air. As the insects are attracted by the light, their transfer from one tube to another was facilitated by pressing the mouths of the tubes together and placing the bottom of the tube to which the insects were to be transferred towards the light. In this way the insects crawled to the tube receiving more light and were thus transferred easily from one tube to another. Dead insects were collected with a sterile platinum loop into separate sterile test tubes at each observation.

TABLE 8.—*Inoculation of hymenopterous parasites of the coconut leaf miner.*

Four insects untreated and used as check.		Six insects allowed to walk on spores.		
Date observed.	Number infected.	Date observed.	Number infected.	Reisolations.
Mar. 20, 1930	All living	Mar. 20, 1930	One died, 8 a. m. One died, 9 a. m.	*Aspergillus* sp.
Mar. 21, 1930	do	Mar. 21, 1930	Two died, 1.30 p. m.; fungus growth visible.	One positive; 1 *Aspergillus* sp.
Mar. 22, 1930	do			
Mar. 24, 1930	do	Mar. 24, 1930	Two died	*Aspergillus* sp.
Mar. 26, 1930	do			
Mar. 28, 1930	do			
Mar. 31, 1930	do			
Apr. 2, 1930	do			
Apr. 8, 1930	do			
Apr. 11, 1930	do			

As given in Table 8, the parasites that were artificially infected died in one to five days after the date of inoculation, while those uninfected lived for twenty-three days, or until April 11, 1930, when observations terminated. Reisolations were made from the inoculated insects of which only one showed the inoculum used, while the rest yielded a species of *Aspergillus*. The results seem to show that the organism is not an active pathogene of the leaf-miner parasites. The failure of the fungus successfully to infect more of the insects may be attributed to the habit of these tiny insects. Like the house fly they are very active and are capable of cleaning themselves by brushing off with their legs water droplets, spores, or any object clinging to their bodies. Being very small the few spores which adhered to them might have fallen of their own weight or through their jerky movements, especially when desiring to fly.

EXPERIMENT II

June 28, 1930, at 11.30 a. m., thirteen leaf-miner larval parasites obtained from Mr. S. S. Gonzales, at Lipa, Batangas Province, the previous day were transferred into a sterile 1-inch test tube containing spores of the fungus, and were allowed to roam around for about two minutes before transferring them into another 1-inch sterile test tube. Thirteen other larval parasites were placed in another large sterile test tube and used as controls. Diluted honey was supplied as food for the insects by putting small droplets on pieces of sterilized coco-palm leaflets.

TABLE 9.—*Artificial infection of larval parasites of the coconut leaf miner.*

Treatment.	Date set.	Insects in each treatment.	Mortality. 1930.			
			June 30.	July 2.	July 11.	July 14.
Inoculated	June 28, 1930	13	[a] 4	9	----------	----------
Control	do	13	None.	12	None.	1

Treatment.	Date set.	Reisolations. 1930.	
		Inoculated.	Control.
Inoculated	June 28, 1930	July 11; 2 doubtful; 7 *Aspergillus* sp.	July 11; 5 *Aspergillus* sp.
Control	do	July 16; 4 *Aspergillus* sp.	July 16; 1 *Aspergillus* sp.

[a] One dying.

As shown in Table 9, four of the inoculated larval parasites died two days after inoculation and one of which was in moribund condition. In two more days all the remaining insects in the inoculated tube perished, while twelve died in the control tube. The lone parasite remaining in the control tube lived until July 14, or sixteen days, from the time the experiment was started. When the reisolations were made from those showing the presence of fungus, two of the inoculated insects showed a white fungus associated with a species of *Aspergillus* but they were not very typical of *Beauveria globulifera.* The other insects gave negative results, while six of the control insects yielded a species of *Aspergillus.* The contaminating organism that developed on both the inoculated and control insects was probably present on them before the inoculations were made because the original locality from which the insects came was a very humid place.

EXPERIMENT III

Following the same treatment and method of inoculation a third trial was made. July 31, 1930, abundant spores obtained from a fresh culture of the fungus were spread on the inner surface of a 1-inch sterile test tube and into it were placed newly emerged parasites obtained from Mr. C. Buligan, of the Bureau of Plant Industry at Magdalena, Laguna Province, the previous day. Twenty-seven parasites were allowed to roam about for four minutes before allowing them to return to their former confinement—another large sterilized test tube. Diluted honey in fine droplets placed on pieces of sterilized coco-palm pinnæ was supplied as food. Thirty uninoculated parasites were released in the same-sized test tube and given the same food. The results are shown in Table 10.

It will be seen from the results tabulated that the inoculated insects died much sooner, while at the close of the experiment August 9, 1930, eighteen of the untreated insects were still alive and two remained healthy until September 7, 1930. Eleven insects showing fungous growth in the inoculated lot and two of the controls yielded a species of *Aspergillus* and were, therefore, negative. Just how these insects picked up the contaminating organism cannot be explained.

The three preceding experiments tend to show that the fungus is not an aggressive pathogene of the coconut leaf-miner parasites, although the tests were not so extensive as to warrant definite conclusions. There is little likelihood, however, that these so-called larval parasites would fall easy prey to the fungus because they are hidden with the larvæ and pupæ they attack

TABLE 10.—*Artificial inoculation of larval parasites of the coconut leaf miner.*

Treatment.	Insects used.	Date observed.	Mortality in inoculation.	Mortality in control.
Inoculated	27	1930 Aug. 2	Eleven died: 5 showed fungous growth; 2 died in honey.	None.
Check	30	Aug. 4	Thirteen died: 6 showed fungous growth; 1 died in honey.	Two died; no fungous evidence.
		Aug. 5		Three died; no fungous evidence.
		Aug. 6		One died in honey.
		Aug. 7		Three died in honey.
		Aug. 8		None.
		Aug. 9		Two died; 1 drowned, apparently.

Reisolations.

Inoculated.	Control.
Eleven insects yielded mold; no fungus developed in the rest.	Two insects developed mold while the others none.

within the leaf tissues. In other words, these parasites are protected not only by the thick epiderma of the coco leaves but also by the coating of their hosts where they pass the greater part of their life. As these parasites become full grown, they pass out of the leaves through tiny punctures made in the epidermis and probably live on other hosts during this intervening period until they are able to lay eggs, or die without perpetuating their species. Many of them probably succumb to adversities of weather, while numerous others are perhaps destroyed by their predators and hyperparasites.

SUMMARY AND CONCLUSIONS

This paper reports primarily the results obtained from experimental attempts to infect artificially the adult coconut leaf miner, *Promecotheca cumingi* Baly, with a fungus which has proved identical with *Beauveria globulifera* (Speg.) Pic.

The opinion or observation of previous investigators that when an insect pest has reached its maximum numbers or becomes excessively numerous a fungous epidemic generally ensues, did not hold true with the coconut leaf miner. However, a few isolated cases of inactive fungous pathogenes have been encountered. Their development and spread are greatly dependent upon weather and climatic conditions.

Several methods were employed with varying degrees of success in artificially inducing the disease on the coconut leaf miner; namely, by dusting the beetles with spores; by spraying them with spores in water suspension; by applying spores on some individuals and releasing them with the healthy ones (or by natural contact); by spraying the lower surfaces of the coco leaves they eat with a spore suspension; and by spraying the beetles with a suspension of spores while they are feeding on the leaves. Under natural conditions the last method proved to be the most effective, causing a high percentage of fatality, because of exposure of the insects to both external and internal infection. Spraying is also more feasible because the beetles do not usually fly in the daytime even if disturbed, except at dusk and at dawn.

The infectious nature of the fungus has been demonstrated by experiments conducted under properly controlled conditions. In tests conducted in large wire cages in the open, or under conditions approaching to some extent those found in nature, the organism proved a pathogene of considerable importance to healthy beetles of the coconut leaf miner, causing 44 to 67.4 per cent mortality. Under greenhouse conditions, positive results were also obtained, the mortality ranging from 7.3 to 73.2 per cent, depending on the method of inoculation or propagation employed. The course of the disease was the same as on its natural host.

The experiments carried out in the open were not extensive enough and further tests should be made in the coco-palm regions to determine more definitely the efficacy of this fungus before recommendations can be made.

That this parasitic locust fungus can be artificially communicated to healthy beetles of the coconut leaf miner evidently proves the pleophagous nature of the organism.

The viability of the spores of the fungus sprayed on the coco-palm leaves was found by tests to last two months and nine days, but further tests would probably reveal that the spores will remain viable for a much longer period, especially if spores are applied more abundantly to facilitate detection. The value of the test lies in the fact that the longer the spores remain viable the greater the chance for the insects to be infected.

Although *Sporotrichum globuliferum* and other species of *Sporotrichum* have been reported to infect many kinds of plants, the healthy coco palms seemed apparently immune to it.

On the whole, all attempts to infect the hymenopterous or so-called larval parasites have ended in failure, indicating that this fungus is probably not an aggressive pathogene of these tiny insects. There seems to be little fear of these beneficial insects falling ready victims to the fungus as they spend the greater part of their life cycle within the coco leaves and are thus protected, not only by their thick, more or less glossy or waxy epiderma, but also by the coatings of the larvæ and pupæ in which they hibernate. It is not definitely known where the parasites spend the rest of their mature life. Being short-lived animals it is presumed that they are either destroyed by their predators and hyperparasites or that they die a natural death after perpetuating their species.

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ILLUSTRATIONS

PLATE 1

Coconut leaf miner beetles, *Promecotheca cumingi* Baly, infected by dusting with spores dislodged from a fresh culture of *Beauveria globulifera* (Speg.) Pic. (The presence of the fungus in the mass at the top can be seen clearer with the aid of a magnifier.) Compare the dull appearance of the infected beetles with the shiny and darker, control beetles at the bottom. Photographed six days after date of infection. Approximately × 1.6.

PLATE 2

The eight coconut leaf-miner beetles to the left show the characteristic growth of the inoculum, indistinguishable from one another, distributed irregularly in patches over the head and ventral side, in comparison with the uninoculated ones to the right. About 2.5 times natural size.

PLATE 3

Three adult coconut leaf-miner beetles, greatly enlarged, to show conspicuously the fungus produced by spraying with spores in suspension. Note the luxuriant, cottony-white growth of fine filaments enveloping the insects and forming a more or less furry coating, especially over the body sutures.

PLATE 4

Coconut leaf-miner beetles stuck fast by the fungous growth to the lower surfaces of coco-palm pinnæ as a result of artificial infection, dying in their natural position. The beetles on portions of two leaflets to the right were a result of dipping the beetles in spore dilution while the other beetles on the two other leaflets to the left were a result of spraying the undersurfaces with a spore suspension before allowing the beetles to eat. The narrow longitudinal scars on the leaves show the hypogenous attack. Natural size.

PLATE 5

A sample of the cages used for outdoor infection of the coconut leaf-miner beetle, having narrow strips of wooden frame-work, a wire top and sides and a wooden floor, measuring 1.5 meters high, 0.9 meter wide, and 0.9 meter deep. The legs stand in shallow dishes containing lysol solution.

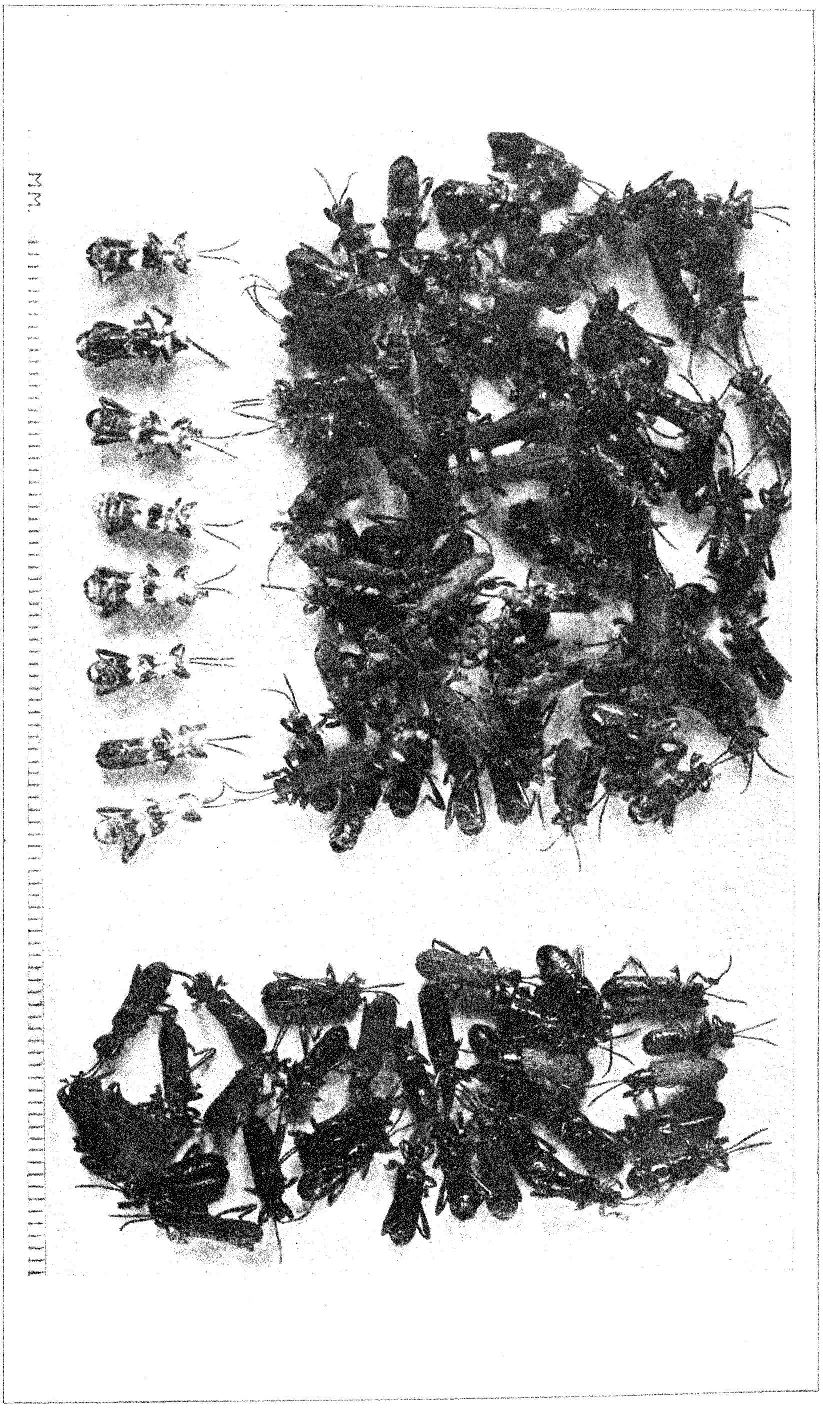

PLATE 1.

UNIV. OF MICH.

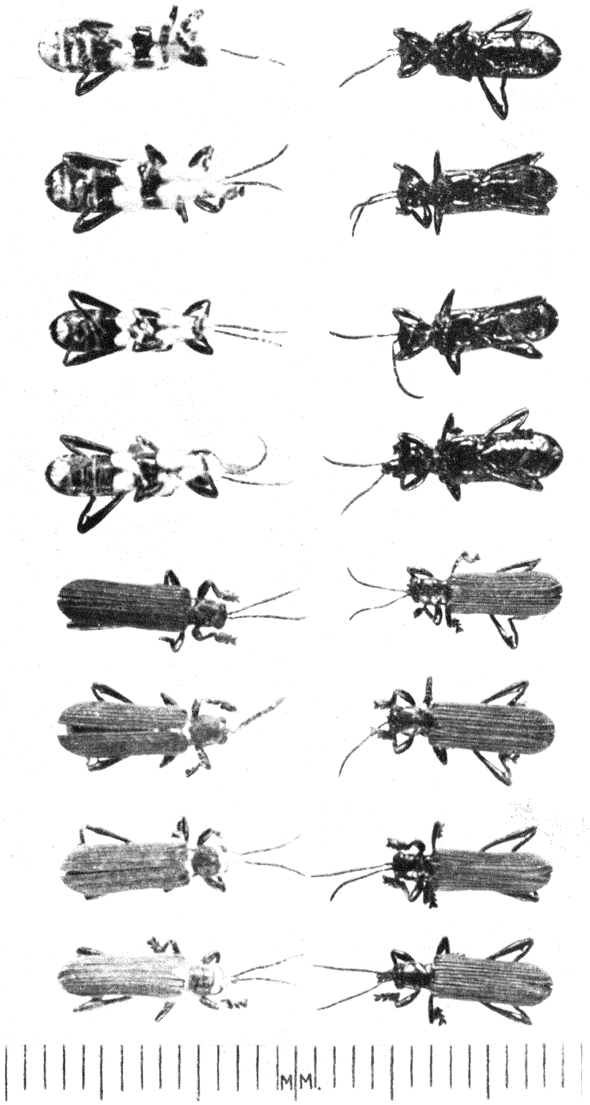

PLATE 2.

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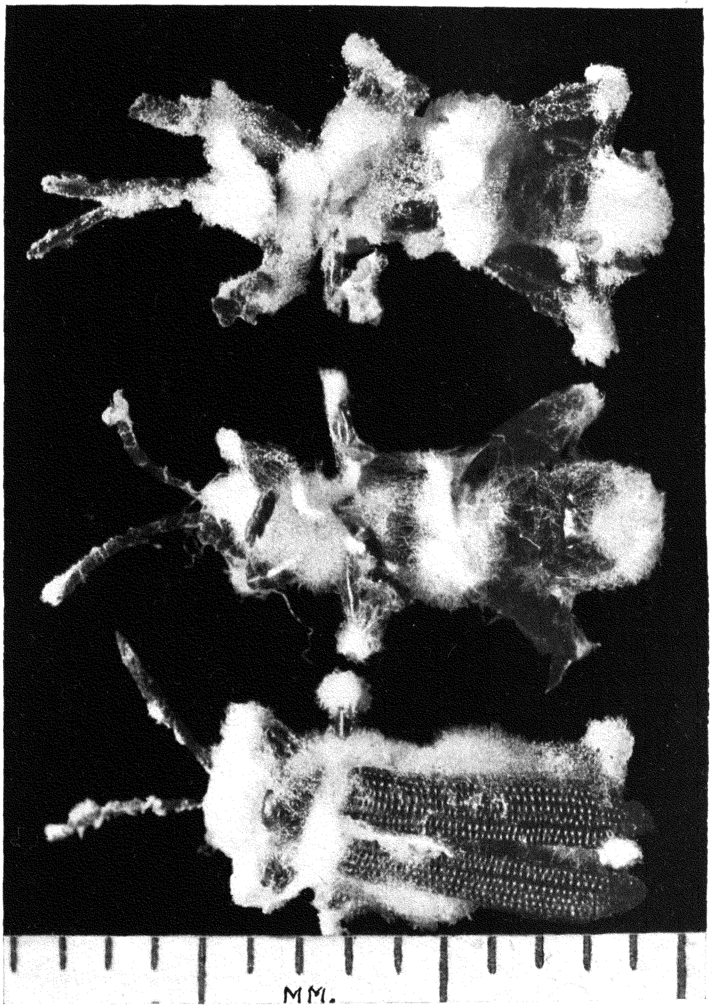

PLATE 3.

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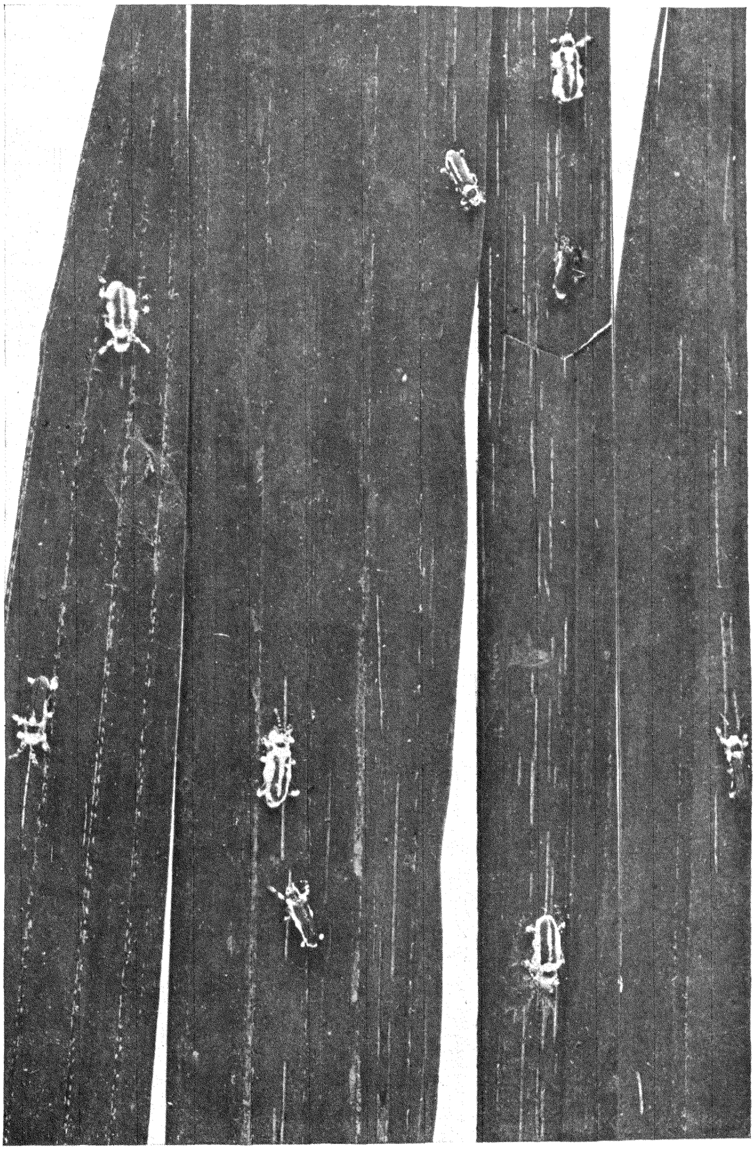

PLATE 4.

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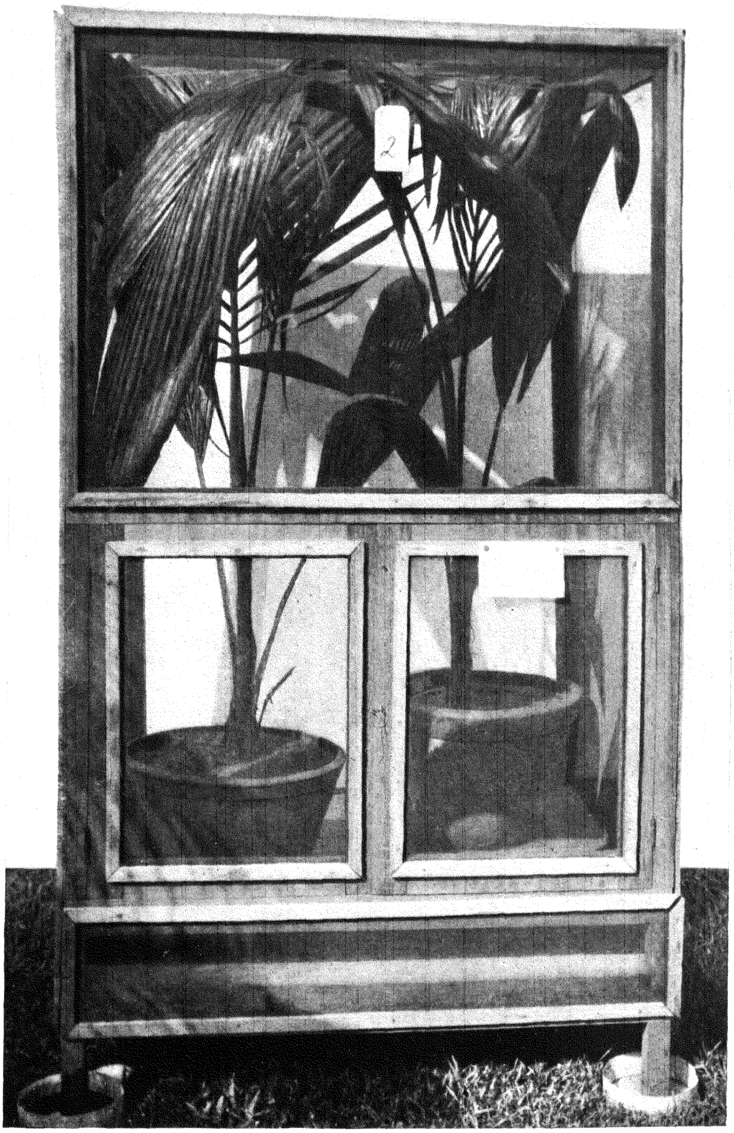

PLATE 5.

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THE PHILIPPINE SPECIES OF PARASTERINA

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FIFTEEN PLATES

In this paper sixteen species of Philippine *Parasterina* have been studied, two of which are new. A key for the species has been prepared, as well as a short key to include the genera closely related to *Parasterina*. All descriptions and illustrations have been prepared from specimens available in the herbaria of the Bureau of Science, Manila, and the College of Agriculture, University of the Philippines, Los Baños, Laguna.

INTRODUCTION

The family Microthyriaceæ, to which the old genus *Asterina* and the new genus *Parasterina* belong, constitutes a very large group of fungi generally found in great abundance in the Tropics. They are mycologically interesting on account of their color shades, which vary from a beautiful transparent green to amber or dark brown, and because of the different shapes of the numerous hyphopodia that are present in many of the genera.

HISTORY

The genus *Asterina*, from which *Parasterina* was separated, is an old one founded by Léveillé.[1] In earlier work this was interpreted to include the paraphysate species now placed in *Parasterina*. These became so numerous, however, that the new genus was established to include them.

There have been diverse opinions as to what species should be taken as the generic type of *Asterina*. Theissen[2] first proposed that *A. azarae* be adopted since Léveillé's type, *A. melastomatis*, is missing, and since the specimens named by Léveillé and deposited in different herbaria are not in accord. Subsequently, Theissen[3] advocated that the Parisian collection of *A. melastomatis* be regarded as the type, but for certain plausible reasons he finally decided that it would be better to return to his original proposal, and take as the type *A. azarae,* a species that has no paraphyses. H. and P. Sydow[4] supported Theissen's idea and added further that if the paraphysate *A. melastomatis* were taken as the type of the genus *Asterina* only a very small number of species could be included under it, while many, if not all, of those without paraphyses would be included under the genus *Dimerosporium,* where *D. abjectum* Fuck. (= *Asterina veronicae*) is the representative type. This would obviously be faulty since over one hundred currently accepted species of *Asterina* would come under *Dimerosporium* as now understood, this being an entirely different genus established long before. It was, therefore, decided to divide all species of *Asterina* into two groups; those without paraphyses with *A. azarae* (*Dimerosporium abjectum* Fuck.) as the type are to be retained under the genus *Asterina* and those with paraphyses are to be assigned to a new genus *Parasterina* of which *Parasterina melastomatis* (Lev.) Theiss. (= *Asterina melastomatis*) is the type.

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[1] Ann. Sci. Nat. 3 (1845) 59.

[2] Fragmenta brasilica V nebst Besprechung einiger Microthyriaceen, Ann. Mycol. 10 (1912) 164.

In order to distinguish the genera that are closely related to *Parasterina,* a key patterned after that of Theissen[5] is presented.

Key to the genera.

1. Mycelium present, hyphopodia or knotted mycelial hyphæ present.
  2. Paraphyses present .... *Parasterina.*
  2. Paraphyses absent .... *Asterina.*
1. Mycelium present; hyphopodia absent.
  2. Spores brown .... *Asterinella.*
  2. Spores colorless .... *Calothyrium.*
1. Mycelium wanting.
  2. Spores brown .... *Seynesia.*
  2. Spores colorless .... *Microthyrium.*

Genus PARASTERINA Theissen and Sydow

Parasterina THEISSEN and SYDOW, Ann. Mycol. 15 (1917) 420.

Mycelium present, superficial, with hyphopodia or knotted cells; mycelial conidia one-celled or absent. Fruiting bodies roundish, flat, or hemispherical, radial, with central opening, radially splitting in the process of development, the surface very often sloughing off to a considerable degree. Hypothecium flat or somewhat concave, colorless. Basal membrane present or absent. Hymenium simple, with many asci. Asci ovoid to globose, thick walled, 8-spored. Paraphyses always present, often thickened at the top, slimy and agglutinate, forming a distinct epithecium. Spores brown, 2-celled.

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[3] Cfr. die Gatung Asterina, Abh. der K. K. Zooligisch Botanischen Gessell Shaft Band 7 (1912–1913) 213.

[4] Ann. Mycol. 15 (1917) 245–246.

[5] Le genre Asterinella, Brotéria: Série Botanica 10 (1912) 104–124.

Key to the species of Parasterina Theissen and Sydow.

1. Spores either spiny, warted, or with a roughened gelatinous surface.
  2. Spores spiny.
    3. Spines slender; hyphopodia 1-celled, abundant, distinctly lobed. 15. *P. spinosa.*
    3. Spines coarse; hyphopodia 1-celled, few, never lobed. 16. *P. tayabensis.*
  2. Spores warted.
    3. Hyphopodia 1-celled, rare, apex rounded or slightly lobed. 4. *P. dilleniae.*
    3. Hyphopodia 2-celled, numerous, apex distinctly lobed. 8. *P. jasminicola.*
  2. Spores with a roughened gelatinous surface, 2- to 4-lobed. 3. *P. cipadessae.*
1. Spores smooth.
  2. Spores subacute at both ends, cylindrical.......................... 2. *P. canthi.*
  2. Spores rounded at both ends, either elliptical or oblong.
    3. Hyphopodia rounded at the apex to very slightly lobed.
      4. Perithecia often in clusters, cylindrical, occasionally rounded; spores 15 to 17 μ long, 8 to 9 μ wide.......................... 9. *P. litseae.*
      4. Perithecia not in clusters, rounded; spores 18 to 25 μ long, 10 to 12 μ wide .... 1. *P. astroniae.*
    3. Hyphopodia distinctly lobed but not flabellilobed.
      4. Perithecia usually long, cylindrical, occasionally rounded. 7. *P. homalomenae.*
      4. Perithecia rounded.
        5. Spores 19 to 21 μ long, 9 to 11 μ wide........ 10. *P. momordicae.*
        5. Spores 14 to 16 μ long, 6 to 8 μ wide............ 14. *P. samarensis.*
    3. Hyphopodia flabellilobed.. 11. *P. nycticaliae.*
    3. Hyphopodia never lobed, rounded at the apex.
      4. Perithecia rounded to cylindrical.
        5. Spores banded .... 12. *P. pemphidioides.*
        5. Spores bandless .... 13. *P. ramosii.*
      4. Perithecia rounded, never cylindrical.
        5. Hyphopodia long, cylindrical, 13 to 16 μ long; asci ovoid; spores 21 to 25 μ long, 11 to 12 μ in diameter............ 6. *P. fagarae.*
        5. Hyphopodia short, cylindrical, 10 to 12 μ long; asci oblong to ovoid; spores about 20 μ long, 5 μ in diameter. 5. *P. eugeniae.*

1. PARASTERINA ASTRONIAE (Yates) comb. nov. Plate 1, figs. 1 to 5.

Asterina astroniae YATES in Philip. Journ. Sci. Bot. 12 (1917) 370.

Fungous colony forming suborbicular to round, marginate spots, 4 to 8 millimeters in diameter, oftentimes confluent. Mycelium black, composed of a few, irregularly branching, septate hyphæ 3 to 4 μ wide; branches anastomosing. Hyphopodia unicellular, few, irregularly distributed, ovoid, oblong, generally slightly lobate, 5 to 6 μ long, 4 to 6 μ in diameter. Perithecia numerous, suborbicular to round, 160 to 200 μ in diameter; walls splitting, composed of dark brown hyphæ, 2 to 4 μ wide; periphery slightly fringed.

Asci subglobose to ovoid, 45 to 55 μ long, 28 to 34 μ in diameter. Spores heaped together, oblong, rounded at both ends, constricted at the single septum, dark brown, frequently with the cell contents contracted, 18 to 25 μ long, 10 to 12 μ in diameter.

SAMAR, Catubig River, *Bur. Sci. 24269 M. Ramos* (type in Bur. of Sci. herb.), March 21, 1916, on *Astronia* sp.

2. PARASTERINA CANTHI (Yates) comb. nov. Plate 2, figs. 1 to 5.

Asterina canthi YATES in Philip. Journ. Sci. Bot. 13 (1918) 372.

Forming epiphyllous, black, irregular, crestlike spots, 5 to 6 millimeters in diameter, sometimes covering the whole surface of the leaf. Mycelium abundant, attached to the surface of the leaf, composed of dark brown hyphæ, 5 to 8 μ wide; branches anastomosing, opposite to alternate. Hyphopodia very numerous, opposite, unicellular, oblong to cylindrical, rounded at the apex, about 5 μ long, 4.5 μ wide. Perithecia round, black, opaque; periphery fringed, 90 to 120 μ in diameter; texture subparenchymatous, the wall splitting irregularly.

Asci usually cylindrical, occasionally oblong, 30 to 40 μ long, 8 to 10 μ in diameter. Spores cylindrical, constricted at the single septum, dark brown, subacute at both ends, 10 to 12 μ long, 3 to 3.5 μ in diameter.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27826 M. Ramos* (type in Bur. of Sci. herb.), March 2, 1917, on *Canthium* sp.

3. PARASTERINA CIPADESSAE (Yates) comb. nov. Plate 3, figs. 1 to 5.

Asterina cipadessae YATES in Philip. Journ. Sci. Bot. 12 (1917) 371.

Epiphyllous, forming black spots, at first 2 to 4 millimeters, but soon running together and more or less covering the surface of the leaf. Mycelium composed of branched, anastomosing hyphæ, 5 to 7 μ wide. Hyphopodia numerous, 1-celled, for the most part opposite, sometimes alternate, or irregular, 2- to 4-lobed, 7 to 10 μ long. Perithecia numerous, 150 to 200 μ in diameter, dark brown, subopaque, usually globose, sometimes elliptical, walls splitting irregularly, composed of radiating, septate hyphæ, 3 to 4 μ wide, slightly fringed.

Asci ovoid, 35 to 45 μ long, 22 to 27 μ in diameter. Spores oblong, rounded at both ends, 1-septate, constricted at the middle, dark brown, rough, gelatinous, 28 to 32 μ long, 10 to 12 μ in diameter.

LUZON, Kalinga Subprovince, *Bur. Sci. 25307 H. S. Yates* (type in Bur. Sci. herb.), March 30, 1916, on leaves of *Cipadessa baccifera.*

Yates mentions in his description that the spores of this fungus are papillate. In the many examinations made on the type specimen no such papillate spores were seen; those found have a rough, gelatinous coating.

4. PARASTERINA DILLENIAE (Sydow) comb. nov. Plate 4, figs. 1 to 6.

Asterina dilleniae SYDOW in Philip. Journ. Sci. Bot. 9 (1914) 181.

Spots circular, 2 to 5 millimeters wide, dark gray, forming on the upper surface of the leaf. Mycelium radiating, composed of dark, chestnut brown, regularly spaced hyphæ, 7 to 9 μ long; branches with long beaks. Hyphopodia rare, alternate to one sided, 1-celled, globose, truncate to short cylindrical, chestnut brown, rounded at the end or somewhat lobed or angular, 10 to 15 μ long, 9 to 11 μ wide. Perithecia rare, flat, inverted, round, 140 to 200 μ in diameter; walls splitting, slightly black, opaque, composed of hyphæ, 4 to 5 μ wide.

Asci globose to ovoid, 40 to 50 μ long, 35 to 45 μ in diameter. Spores conglobate, oblong, broadly rounded at both ends, 1-septate, constricted at the middle, dark brown, warted, 20 to 25 μ long, 10 to 12 μ in diameter.

PALAWAN, Taytay, *Bur. Sci. 8774 E. D. Merrill* (cotype in Bur. of Sci. herb.), April 10, 1913.

5. PARASTERINA EUGENIAE (Yates) comb. nov. Plate 5, figs. 1 to 5.

Asterina eugeniae YATES in Philip. Journ. Sci. Bot. 12 (1912) 371.

Forming round to irregular, often marginate, spots up to 10 millimeters wide on the lower surface of the leaf, although sometimes on the upper surface. Mycelium effused, composed of a few, loose, dark brown, septate hyphæ, 4 to 5 μ wide; branches anastomosing. Hyphopodia few, alternate to irregular, cylindrical, rounded at the apex, 10 to 12 μ long, 5 to 7 μ wide.

Perithecia numerous, black, opaque, 225 to 274 μ diameter, perforated at the center; walls composed of radiating hyphæ, 3 to 5 μ wide.

Asci oblong to ovoid, 50 to 60 μ long, 20 μ in diameter. Spores oblong, rounded at the apices, 1-septate, constricted at the middle, brown, 20 μ long, 5 μ in diameter, upper cell the larger.

LUZON, Rizal Province, Antipolo, *Bur. Sci. 22700 M. Ramos,* June 14, 1915, on leaves of *Eugenia* sp., *Bur. Sci. 25070 H. S. Yates and M. Ramos,* September 23, 1915: Batangas Province, Pitong Sanay, *Bur. Sci. 22678 M. Ramos and D. Deroy* (type in Bur. of Sci. herb.), on leaves of *Eugenia* sp.

6. PARASTERINA FAGARAE (Yates) comb. nov. Plate 6, figs. 1 to 5.

Asterina fagarae YATES in Philip. Journ. Sci. Bot. 13 (1918) 373.

Fungous colony epiphyllous, forming round to irregular, black spots, 4 to 7 millimeters wide, sometimes running together and covering the whole surface of the leaf. Mycelium radiating, composed of a few, loose hyphæ, amber to dark brown, septate, 4 μ wide; branches effused, anastomosing. Hyphopodia few, generally alternate, although sometimes irregular, long, cylindrical, 13 to 16 μ long, 4 to 6 μ wide. Perithecia 125 to 150 μ in diameter.

Asci ovoid, 50 to 56 μ long, 36 to 39 μ in diameter. Spores heaped together, oblong, rounded at both ends, 1-septate, constricted at the middle, hyaline when young, brown when mature, smooth, 21 to 25 μ long, 11 to 12 μ in diameter.

LUZON, Rizal Province, *Bur. Sci. 26762 M. Ramos* (type in Bur. of Sci. herb.), October-November, 1916, on leaves of *Fagara avicennae* (= *Zanthoxylum avicennae*).

7. PARASTERINA HOMALOMENAE sp. nov. Plate 7, figs. 1 to 5.

Colonia fungosa, epiphylla, maculas parvas, rotundas, usque ad 8 mm. diam. plus minusve aequabiliter per folii superficiem sparsas efformans; mycelio sat abundanti ex hyphis sinuosis, sucineis vel fuscis, 4 ad 6 μ latis composito; hyphopodiis numerosis, lobatis, generatim oppositis, nonnumquam alternatis, 6 ad 12 μ longis, 5 ad 9 μ latis; peritheciis haud affluentibus, generatim cylindraceis sed saepenumero globosis, 180 ad 223 μ longis, 120 ad 403 μ latis; quoad corticem dehiscentibus, ex hyphis sinuosis compositis, 3 ad 4 μ latis; ambitu fimbriatis; ascis generatim globosis sed nonnumquam ovoideis, 29 ad 31 μ longis, 22 ad 26 μ in diametro; sporidiis oblongo-ellipsoideis, 1-septatis, medio constrictis laevibus, fuscis 14 ad 20 μ longis, 8 ad 11 μ in diametro; loculo superiore multo majore.

Fungous colony epiphyllous, forming small round spots up to 8 millimeters in diameter, more or less uniformly scattered on the surface of the leaf. Mycelium rather abundant, composed of sinuous hyphæ, amber to dark brown, 4 to 6 μ wide. Hyphopodia numerous, lobed, generally opposite, occasionally alternate, 6 to 12 μ long, 5 to 9 μ wide. Perithecia not abundant, commonly cylindrical but often globose, 180 to 223 μ long, 120 to 403 μ in diameter, walls splitting, composed of sinuous hyphæ, 3 to 4 μ wide; periphery fringed.

Asci usually globose, sometimes ovoid, 29 to 31 μ long, 22 to 26 μ in diameter. Spores oblong-ellipsoid, 2-celled, constricted at the middle, smooth, brown, 14 to 20 μ long, 8 to 11 μ in diameter, superior cell very much larger.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 32104 M. Ramos* (type in Bur. of Sci. herb.), April 30, 1918, on leaves of *Homalomena philippinensis.*

This fungus is allied to *Parasterina spinosa* in the characters of the hyphopodia. The hyphopodia of the two fungi are 1-celled, distinctly lobed (with lobes that are identical in shape), and have no definite arrangement. However, the main difference between the two fungi is that *Parasterina spinosa* has spiny spores, while *P. homalomenae* has smooth spores.

8. PARASTERINA JASMINICOLA (Yates) comb. nov. Plate 8, figs. 1 to 6.

Asterina jasminicola YATES in Philip. Journ. Sci. Bot. 13 (1918) 373.

Fungous colony on both surfaces of the leaf, forming irregular spots 2 to 6 millimeters in diameter, often more or less distributed over the surface of the leaf. Mycelium composed of flexous, brown hyphæ, 4 to 5 μ wide. Hyphopodia lobed, numerous, 2-celled, irregularly distributed, never opposite; superior cell 5 to 7 μ long, 4 to 5 μ wide. Perithecia numerous, globose, black, opaque, dehiscent, 95 to 120 μ in diameter.

Asci globose, 22 to 26 μ in diameter. Spores oblong-ellipsoid, 1-septate, constricted at the single septum, brown, rounded at both ends, warted, 17 to 19 μ long, 8 to 10 μ in diameter.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27797 M. Ramos* (type in Bur. of Sci. herb.), March 1, 1917, on leaves of *Jasminum* sp.: Bataan Province, Lamao, *Bur. Sci. 23991 M. Ramos*, December 27, 1915, on *Jasminum* sp.

9. PARASTERINA LITSEAE (Yates) comb. nov. Plate 9, figs. 1 to 6.

Asterina litseae YATES in Philip. Journ. Sci. Bot. 13 (1918) 373.

Amphigenous, although more abundant on the upper surface of the leaf, producing irregular patches, more or less covering the whole surface. Mycelium effused, loose, irregular, radiating, consisting of dark brown hyphæ, 3.5 to 4.5 μ wide; branches anastomosing. Hyphopodia few, round to lobed, 1-celled, 7 to 8 μ long, 3 to 5 μ wide, arranged irregularly. Perithecia very numerous, oftentimes in clusters, cylindrical, occasionally round, 100 to 140 μ in diameter; walls splitting, composed of brown hyphæ, 2 to 3 μ wide, which radiate from the ostiole; periphery fringed, with short radiating hyphæ.

Asci ovoid to globose, 28 to 30 μ long, 18 to 24 μ in diameter. Spores ellipsoid, rounded at both ends, 1-septate, constricted at the middle, brown, smooth, 15 to 17 μ long, 8 to 9 μ in diameter.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27842 M. Ramos* (type in Bur. of Sci. herb.), March 12, 1917, on leaves of *Litsea* sp.; Bangui, *Bur. Sci. 27775 M. Ramos,* February 25, 1917, on leaves of *Litsea* sp.

10. PARASTERINA MOMORDICAE (Yates) comb. nov.

Asterina momordicae YATES in Philip. Journ. Sci. Bot. 13 (1918) 374.

Epiphyllous, spots decidedly black, 2 to 4 millimeters broad. Mycelium composed of dark brown, distantly septate hyphæ, 5 to 6 μ wide. Hyphopodia lobed, numerous, irregular, unicellular, 8 to 12 μ long. Perithecia rounded, 80 to 90 μ in diameter, dehiscent, composed of straight, brown, radiating hyphæ, 2.5 to 3 μ wide.

Asci subglobose, 35 to 40 μ long, 22 to 24 μ in diameter. Spores oblong, rounded at both ends, 1-septate, constricted at the middle, brown, smooth, 19 to 21 μ long, 9 to 11 μ in diameter, superior cell the larger.

LUZON, Tayabas Province, Mount Binuang, *Bur. Sci. 28890 M. Ramos and G. Edaño,* May 13, 1917, on leaves of *Momordica* sp.

The above description is the translation of the original Latin diagnosis. I have been unable to find the type specimen.

11. PARASTERINA NYCTICALIAE (Yates) comb. nov. Plate 10, figs. 1 to 5.

Asterina nycticaliae YATES in Philip. Journ. Sci. Bot. 12 (1917) 371.

Spots mostly epiphyllous, rounded to irregular, black, 3 to 5 millimeters in diameter. Mycelium composed of a few, dark brown, septate hyphæ, 5 to 6 μ wide; branches anastomosing, generally opposite. Hyphopodia 1-celled, numerous, often alternate to irregular, flabellilobed, 10 to 11 μ long, 12 to 15 μ wide. Perithecia numerous, globose, flattened, small, 90 to 110 μ in diameter, dark brown, slightly opaque, splitting, composed of radiating hyphæ, 4 to 5 μ wide.

Asci ovoid to subglobose, 8-spored, 26 to 28 μ long, 18 to 20 μ in diameter. Spores oblong, rounded at both ends, 1-septate, constricted at the middle, brown, smooth, 15 to 18 μ long, 7 to 8 μ in diameter.

LUZON, Camarines Norte Province, Basud, *Bur. Sci. 25669 H. S. Yates* (type in Bur. of Sci. herb.), December 11, 1916, on leaves of *Nycticalos cuspidatum;* Paracale, *Bur. Sci. 34018 M. Ramos and G. Edaño,* December 22, 1918, on leaves of *Wrightia* sp.

12. PARASTERINA PEMPHIDIOIDES (Cooke) Theissen. Plate 11, figs. 1 to 4.

Parasterina pemphidioides (Cooke) THEISSEN in Ann. Mycol. 17 (1918) 246.

Forming amphigenous, black, small, irregularly circular spots 5 to 8 millimeters in diameter, soon coalescing, sometimes almost covering the surface of the leaf. Mycelium floccose, brown, laterally branching, anastomosing, composed of regularly septate hyphæ, 4 to 6 μ wide. Hyphopodia fairly numerous, 2-celled, alternate to irregularly 1-sided, truncate to nearly rounded at the end, 9 to 17 μ long, 6 to 9 μ wide. Perithecia numerous, shiny, hemispherical, rounded to long cylindrical, 100 to 300 μ diameter, splitting, composed of amber-colored hyphæ, 3 to 4 μ wide.

Asci obovoid to almost rounded, 35 to 41 μ long, 25 to 30 μ in diameter. Spores ellipsoid, constricted at the single septum, brown, banded, superior cell the larger, 25 to 30 μ long, 9 to 12 μ in diameter.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27833 M. Ramos,* March 15, 1917, on *Eugenia jambolana:* Benguet Subprovince, *Bur. Sci. 32091 J. K. Santos,* June 9, 1918, on *Eugenia* sp.: Isabela Province, Palanan Bay, *Sydow Fungi exotici exsicati 270 L. Escritor,* June, 1913, on *Eugenia subrotundifolia:* Tayabas Province, Guinayangan, *Bur. Sci. 20924 E. D. Merrill,* May, 1913, on *Eugenia* sp.: Bataan Province, Mount Mariveles, *Bur. Sci. 19075 P. W. Graff,* November, 1912, on *Eugenia* sp.: Rizal Province, *Bur. Sci. 23951 M. Ramos,* December 14, 1915, on *Eugenia calubcob;* Morong, *Bur. Sci. 23892 M. Ramos,* November 23, 1915, on *Eugenia jambolana:* Camarines Norte

Province, Paracale, *Bur. Sci. 33972 M. Ramos and G. Edaño* December 11, 1918, on *Shorea* sp. PALAWAN, Mount Capoas, *Bur. Sci. 9082 E. D. Merrill,* April 21, 1913; Taytay, *Bur. Sci. 8738, 8788 E. D. Merrill,* April 10, 1913, on *Eugenia* sp. BUSUANGA, Concepcion, *Bur. Sci. 41443 M. Ramos,* September 8, 1922, on *Eugenia.* SULU ARCHIPELAGO, Bengas Island, *Bur. Sci. 36158 H. S. Yates,* October 27, 1919.

The above description is taken from a topotype (*Bur. Sci. 21902 M. Ramos*), collected near Antipolo, Rizal Province, August, 1915, on *Eugenia jambolana,* which according to Theissen[6] agrees closely with the type specimen in having large, banded spores.

This species is allied to *Parasterina incisa,*[7] of India, but differs in its smaller spores, and to *Parasterina japonica* Theiss.,[8] of Japan, but differs in having larger asci, and shorter spores, which are not banded.

13. PARASTERINA RAMOSII Sydow. Plate 12, figs. 1 to 5.

Parasterina ramosii SYDOW in Ann. Mycol. **14** (1917) 246.

Epiphyllous, spots at first small, soon coalescing into irregular patches. Mycelium composed of rectangular, chestnut brown hyphæ, 14 to 30 μ long, 5 to 7 μ wide, branching at right angles. Hyphopodia rather numerous, usually, but not constantly opposite, 2-celled, 12 to 18 μ long, 6 to 8 μ wide, cylindrical, straight, not lobed, base cell small. Perithecia at first 200 to 300 μ in diameter, becoming oblong-elliptic and up to 600 μ long, 200 to 300 μ wide, margin fringed, radiating, opaque, stellate, dehiscent.

Asci ellipsoid to ovoid, 50 to 80 μ long, 35 to 45 μ in diameter. Spores dark brown when mature, opaque, 26 to 30 μ long, 12 to 14 μ in diameter.

LUZON, Rizal Province, Antipolo, *Bur. Sci. 23906 M. Ramos* (cotype in Bur. of Sci. herb.), *23923,* November 24, 1915, on *Eugenia jambolana.*

Parasterina ramosii resembles somewhat *P. pemphidioides,* but differs in its opposite hyphopodia and bandless spores. It is allied to *Parasterina japonica* Theiss.,[9] of Japan, but differs in having smaller asci.

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[6] Ann. Mycol. **15** (1917) 246.

[7] Ann. Mycol. **9** (1911) 390.

[8] Gatt. Asterina, In Abh. der K. K. Zoölogisch-Botanischen Gesellshaft (1913) 43, tab. VI, figs. 22–23 et VIII figs. 8, 13, 14.

[9] Gatt. Asterina (1913) 43, tab. VI figs. 22–23 and VIII figs. 8, 13, 14.

14. PARASTERINA SAMARENSIS nom. nov. Plate 13, figs. 1 to 5.

Asterina ramosii YATES in Philip. Journ. Sci. Bot. 13 (1918) 373.

Hypophyllous; spots circular, dark gray, 4 to 10 millimeters in diameter. Mycelium composed of effused, loose, brown, branching, septate hyphæ, 4 to 5 μ wide. Hyphopodia few, alternate to irregular, lobed, 6 to 8 μ long, 5 μ wide. Perithecia numerous, round, subopaque, 80 to 120 μ in diameter, stellate, dehiscent, composed of radiating hyphæ, 4 to 5 μ wide.

Asci ovoid to globose, 18 to 20 μ long, 15 to 17 μ in diameter. Spores conglobate, oblong, sometimes broad, rounded at both ends, 1-septate, constricted at the middle, 14 to 16 μ long, 6 to 8 μ in diameter.

LUZON, Camarines Norte Province, Paracale, *Bur. Sci. 33955 M. Ramos and G. Edaño*, December 18, 1918, on *Dillenia philippinensis*. SAMAR, Catubig River, *Bur. Sci. 24643* (type in Bur. of Sci. herb.), *24637 M. Ramos,* February 20, 1916, on *Dillenia philippinensis*.

The transfer of this fungus to the new genus *Parasterina,* makes its name *Parasterina ramosii,* but, unfortunately another species has been named *Parasterina ramosii.* It is, therefore, necessary to give the Yates fungus another name, and *Parasterina samarensis* is proposed.

Parasterina nycticaliae (Yates) agrees with *P. samarensis* in having identical perithecia, ovoid to globose asci, and oblong spores. It differs, however, in having somewhat smaller spores.

15. PARASTERINA SPINOSA sp. nov. Plate 14, figs. 1 to 5.

Colonia fungosa stricte epiphylla, maculas rotundas, atras, elevatas, 0.5 ad 5 mm latas, dense et sine ordine per folii superficiem sparsas efformans; mycelio exiguo, inter-texto, ex hyphis flavis vel sucineis, densis, septatis, 3 ad 5 μ latis; ramis raris, leviter anastomosantibus; hyphopodiis sat abundantibus, sine ordine dispositis, distincte lobatis; peritheciis affluentibus, globosis, 95 ad 172 μ diam. cortice fusco parte interiore caeruleo-virescente, contextu stellatim facile dehiscentibus, ex hyphis septatis composito, 2 ad 4 μ latis, ambitu nonfimbriatis; ascis sat numerosis, generatim globosis, nonnumquam subglobosis vel ovoideo-globosis, 35 ad 46 μ longis, 29 ad 31 μ in diametro, sporidiis tenuiter spinosis, 1-septatis, medio constrictis, utrinque rotundatis, 22 ad 25 μ longis, 9 ad 10 μ latis, loculo superiore majore.

Fungous colony strictly epiphyllous, forming round, black, elevated spots, ranging from 0.5 millimeter to about 5 millimeters wide, scattered thickly and irregularly over the surface of the leaf. Mycelium sparse, intertwining, composed of straw to beautiful amber-colored, compact, septate hyphæ, 3 to 5 μ wide, branches rare, slightly anastomosing. Hyphopodia abundant, with no definite arrangement, distinctly lobed, stipitate, 9.5 to 11 μ long, 6.5 to 10 μ wide. Perithecia rather abundant, globose, 95 to 172 μ in diameter, outside coating dark brown, inside layer bluish green; wall splitting, composed of septate hyphæ, 2 to 4 μ wide. Periphery not fringed.

Asci quite numerous, usually globose, sometimes subglobose or ovoid-globose, 35 to 46 μ long, 29 to 31 μ in diameter. Spores with slender spines, 2-celled, constricted at the single septum, rounded at both ends, 22 to 23 μ long, 9 to 10 μ in diameter, superior cell the larger.

LUZON, Tayabas Province, Mount Bunuan, *Bur. Sci. 28884 M. Ramos* (type in Bur. of Sci. herb.), May 19, 1919, on *Cissus*.

Parasterina spinosa resembles *Parasterina tayabensis* in having spores that are spiny; however, those of the former are slenderer. In the hyphopodia there is a close similarity with those of *Parasterina homalomenae*. The specific name, *spinosa*, has reference to the spiny character of the spores.

16. PARASTERINA TAYABENSIS (Yates) comb. nov. Plate 15, figs. 1 to 6.

Asterina tayabensis YATES in Philip. Journ. Sci. Bot. 12 (1917) 372.

Spots epiphyllous, rounded, 3 to 4 millimeters wide, finally coalescing and covering large portions of the leaf surface. Mycelium abundant, composed of brown, anastomosing, septate hyphæ, 10 to 12 μ long, 5 to 7 μ wide; branches irregular. Hyphopodia few, scattered, globose to short cylindrical, rounded at the end, one-celled, 10 to 12 μ long, 5 to 7 μ wide. Perithecia numerous, 130 to 200 μ in diameter, slender, stellate, dehiscent, radiating, composed of hyphæ, 2 to 6 μ wide.

Asci subglobose, 30 μ long, 25 μ in diameter. Spores oblong, rounded at both ends, 1-septate, constricted at the middle, with coarse spines, 22 μ long, 10 μ in diameter.

LUZON, Camarines Norte Province, Basud, *Bur. Sci. 25635 M. Ramos* (type in Bur. of Sci. herb.), December 19, 1916, on unknown host.

In Yates's description the specimen is labelled Basiad, Tayabas, but the field label states that the specimen was collected in Basud, Camarines Norte.

Host index to the species.

Host.	Fungus.
Astronia sp. (Melastomataceæ).	*Parasterina astroniae.*
Canthium sp. (Rubiaceæ).	*Parasterina canthi.*
Cissus (Vitaceæ).	*Parasterina spinosa.*
Cipadessa baccifera (Meliaceæ).	*Parasterina cipadessae.*
Dillenia sp. (Dilleniaceæ).	*Parasterina dilleniae.*
Dillenia sp. (Dilleniaceæ).	*Parasterina samarensis.*
Dillenia philippinensis (Dilleniaceæ).	*Parasterina samarensis.*
Eugenia calubcob (Myrtaceæ).	*Parasterina pemphidioides.*
Eugenia jambolana (Myrtaceæ).	*Parasterina pemphidioides.*
Eugenia subrotundifolia (Myrtaceæ).	*Parasterina pemphidioides.*
Eugenia sp. (Myrtaceæ).	*Parasterina eugeniae.*
Eugenia sp. (Myrtaceæ).	*Parasterina pemphidioides.*
Eugenia sp. (Myrtaceæ).	*Parasterina ramosii.*
Fagara avicennae=*Zanthoxylum avicennae* (Rubiaceæ).	*Parasterina fagarae.*
Homalomena philippinensis (Araceæ).	*Parasterina homalomenae.*
Jasminum sp. (Oleaceæ).	*Parasterina jasminicola.*
Litsea sp. (Lauraceæ).	*Parasterina litseae.*
Momordica sp. (Cucurbitaceæ).	*Parasterina momordicae.*
Nycticalos cuspidatum (Bignoniaceæ).	*Parasterina nycticaliae.*
Shorea sp. (Dipterocarpaceæ).	*Parasterina pemphidioides.*
Wrightia (Apocinaceæ).	*Parasterina nycticaliae.*
Unknown host.	*Parasterina tayabensis.*

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ILLUSTRATIONS

PLATE 1. PARASTERINA ASTRONIAE (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a leaf surface showing fungous colony; × 20.
2. Perithecium, with mycelium; × 254.
3. An ascus, with paraphyses and ascospores; × 1431.
4. Two ascospores; × 1431.
5. Mycelium, with hyphopodia; × 1431.

PLATE 2. PARASTERINA CANTHI (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a leaf surface showing fungous colony; × 20.
2. Perithecium, with mycelium and hyphopodia; × 254.
3. Ascus, with ascospores and paraphyses; × 1431.
4. Two ascospores; × 1431.
5. Mycelium, with hyphopodia and a developing perithecium; × 1431.

PLATE 3. PARASTERINA CIPADESSAE (YATES) COMB. NOV.

FIG. 1. Photomicrograph of fungous colony on the leaf surface; × 20.
2. Perithecium, with mycelium; × 254.
3. Ascus, with paraphyses and ascospores; × 1431.
4. Two ascospores; × 1431.
5. Mycelium, with hyphopodia; × 1431.

PLATE 4. PARASTERINA DILLENIAE (SYDOW) COMB. NOV.

FIG. 1. Photomicrograph of fungous colony on the leaf surface; × 20.
2. Perithecium; × 254.
3. Portion of perithecium showing perithecial hyphæ in detail; × 1431.
4. Asci, showing two types, *a* and *b*, with paraphyses and ascospores; × 1431.
5. Two warted ascospores; × 1431.
6. Mycelium, with one-celled hyphopodia; × 1431.

PLATE 5. PARASTERINA EUGENIAE (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface; × 20.
2. Perithecium; × 254.
3. Asci, *a* and *b*, with paraphyses and ascospores; × 1431.
4. Two ascospores.
5. Mycelium, with one-celled hyphopodia.

PLATE 6. PARASTERINA FAGARAE (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia on the leaf surface; × 20.
2. Perithecium, with mycelium; × 1431.
3. Ascus, with ascospores and paraphyses; × 1431.
4. Three ascospores; × 1431.
5. Mycelium, with long, cylindrical, one-celled hyphopodia; × 1431.

PLATE 7. PARASTERINA HOMALOMENAE SP. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia on the leaf surface; × 20.
2. Portion of perithecium, showing wall structure; × 1431.
3. Asci, *a* and *b*, with paraphyses and ascospores; × 1431.
4. Three ascospores; × 1431.
5. Mycelium, with hyphopodia; × 1431.

PLATE 8. PARASTERINA JASMINICOLA (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia; × 20.
2. Perithecium; × 254.
3. Portion of a perithecium, showing wall structure; × 1431.
4. Ascus, with paraphyses and ascospores; × 1431.
5. Three warted ascospores; × 1431.
6. Mycelium, showing hyphopodia; × 1431.

PLATE 9. PARASTERINA LITSEAE (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia; × 20.
2. Perithecia, showing two types, *a* and *b;* × 254.
3. Portion of perithecium, showing wall structure; × 1431.
4. Asci, *a* and *b*, with paraphyses and ascospores; × 1431.
5. Three ascospores; × 1431.
6. Mycelium, with one-celled hyphopodia; × 1431.

PLATE 10. PARASTERINA NYCTICALIAE (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia; × 20.
2. Perithecia, with portion of mycelium.
3. Portion of mycelium, showing wall structure.
4. Two types of asci, *a* and *b*, with paraphyses and ascospores.
5. Mycelium, with two fork-lobed hyphopodia.

PLATE 11. PARASTERINA PEMPHIDIOIDES (COOKE) THEISSEN

FIG. 1. Photomicrograph of a fungous colony on the leaf surface, showing perithecia; × 20.
2. Perithecia, showing two types, *a* and *b;* × 254.
3. Two types of asci, *a* and *b*, with paraphyses and ascospores; × 1431.
4. Two ascospores, showing banded character; × 1431.

PLATE 12. PARASTERINA RAMOSII SYDOW

FIG. 1. Photomicrograph of a fungous colony, showing perithecia on the leaf surface; × 20.
2. Perithecia, showing two types, *a* and *b;* × 254.
3. Ascus, with paraphyses and ascospores; × 1431.
4. Two ascospores; × 1431.
5. Mycelium, with opposite, two-celled hyphopodia; × 1431.

PLATE 13. PARASTERINA SAMARENSIS NOM. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia; × 20.
2. Perithecium; × 254.
3. Two types of asci, *a* and *b*, with paraphyses and ascospores; × 1431.
4. Three ascospores; × 1431.
5. Mycelium, with many lobate hyphopodia; × 1431.

PLATE 14. PARASTERINA SPINOSA SP. NOV.

FIG. 1. Photomicrograph of a fungous colony, showing perithecia; × 20.
2. Portion of perithecium with mycelium; × 254.
3. Asci, *a* and *b*, with paraphyses and ascospores; × 1431.
4. Two spiny ascospores; × 1431.
5. Mycelium, with lobate hyphopodia; × 1431.

PLATE 15. PARASTERINA TAYABENSIS (YATES) COMB. NOV.

FIG. 1. Photomicrograph of a fungous colony on the leaf surface, showing the perithecia; × 20.
2. Perithecium, showing peculiarity of splitting; × 254.
3. Portion of perithecium, showing arrangement of hyphæ; × 1431.
4. Ascus, with paraphyses and ascospores; × 1431.
5. Three spiny ascospores; × 1431.
6. Mycelium, with one-celled hyphopodia; × 1431.

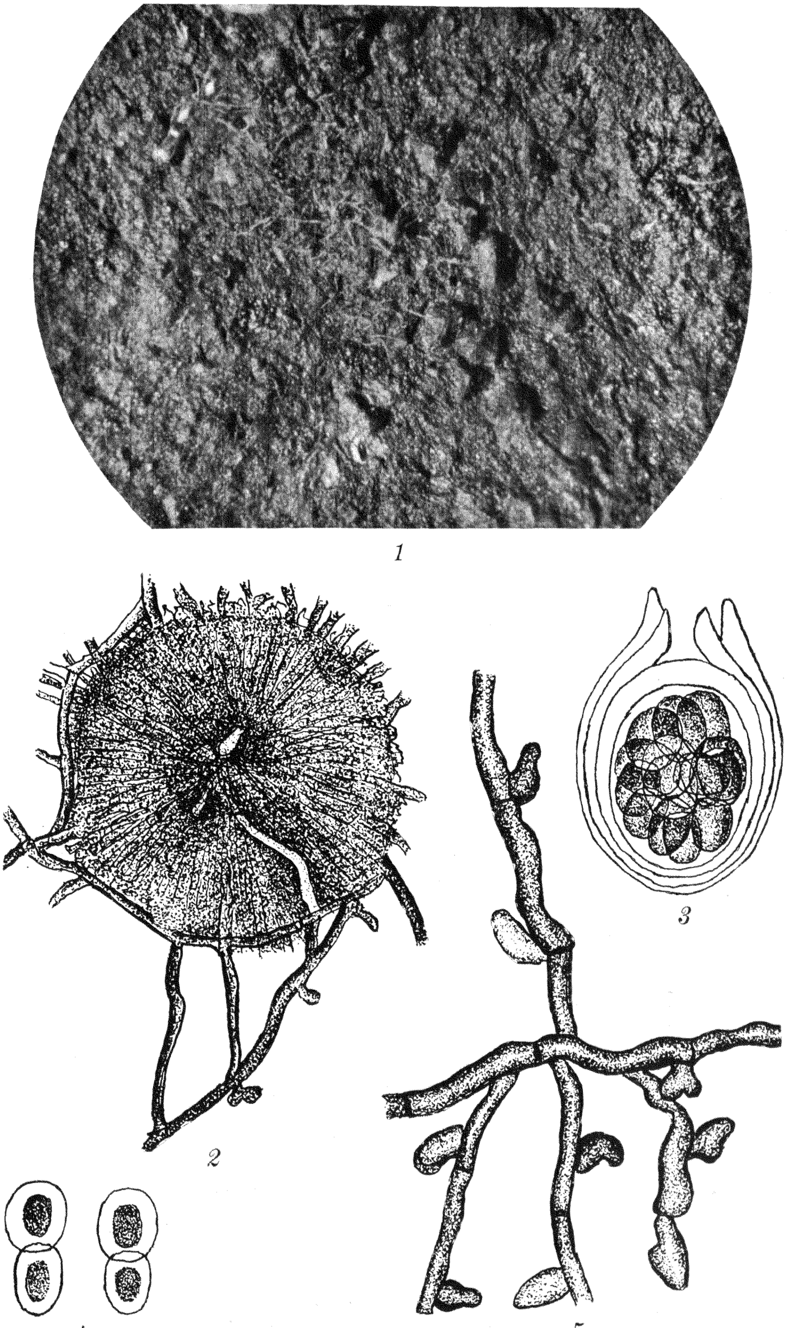

PLATE 1.

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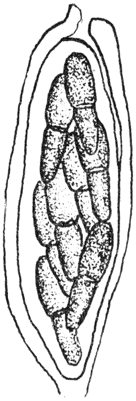

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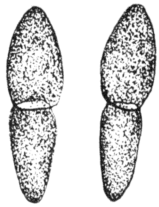

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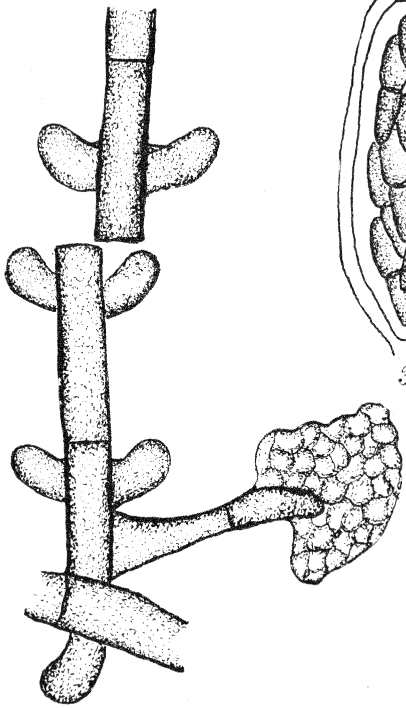

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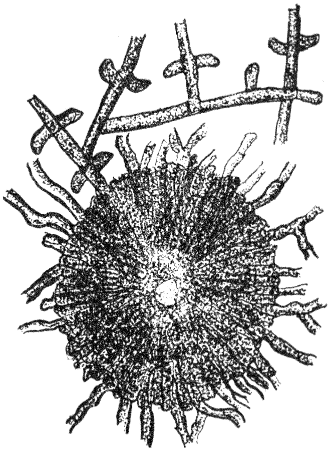

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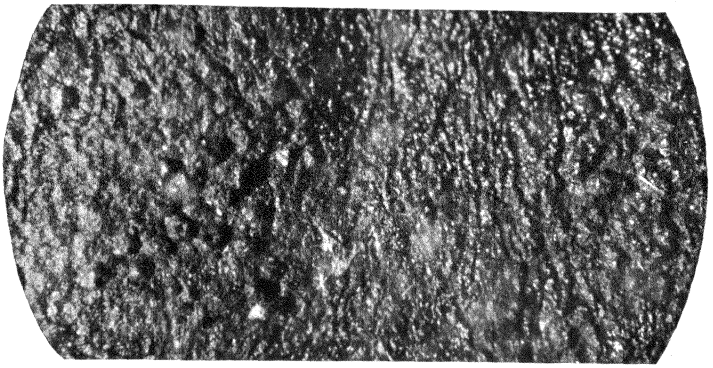

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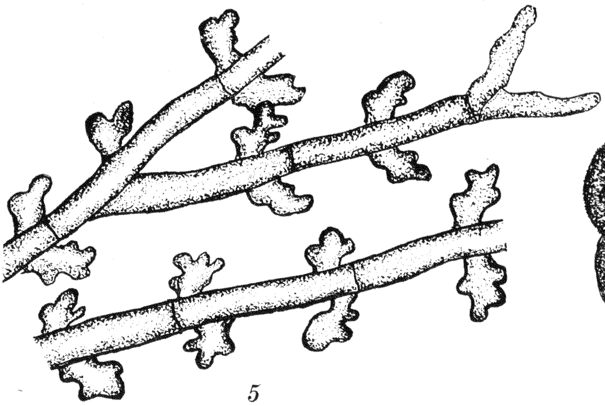

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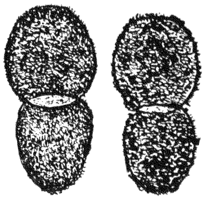

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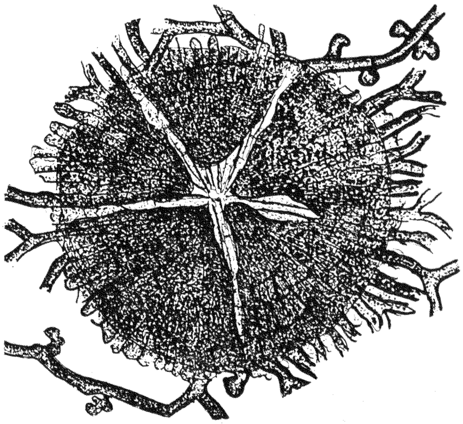

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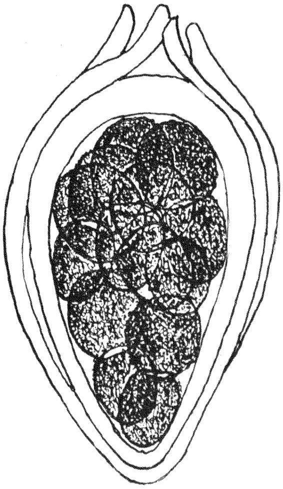

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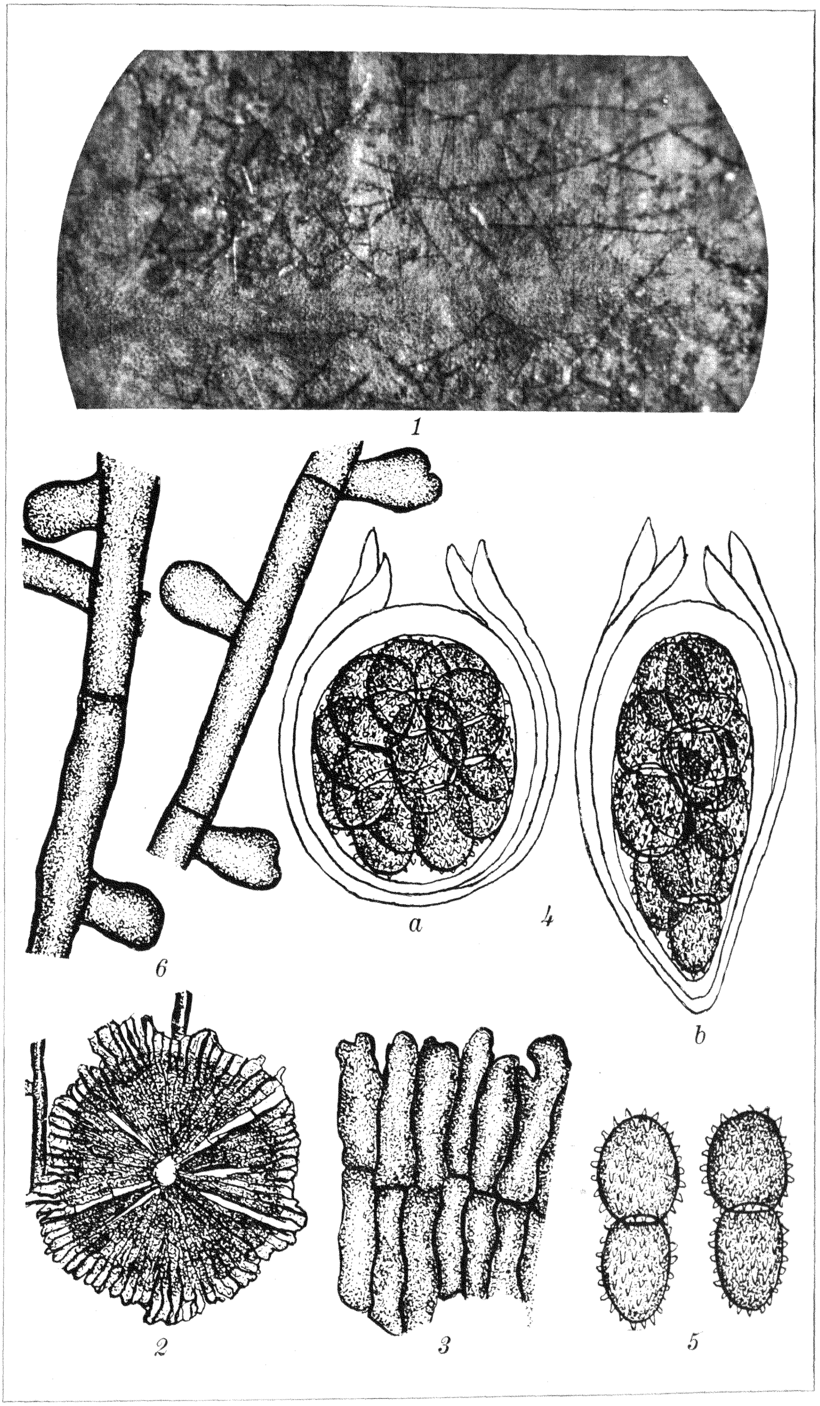

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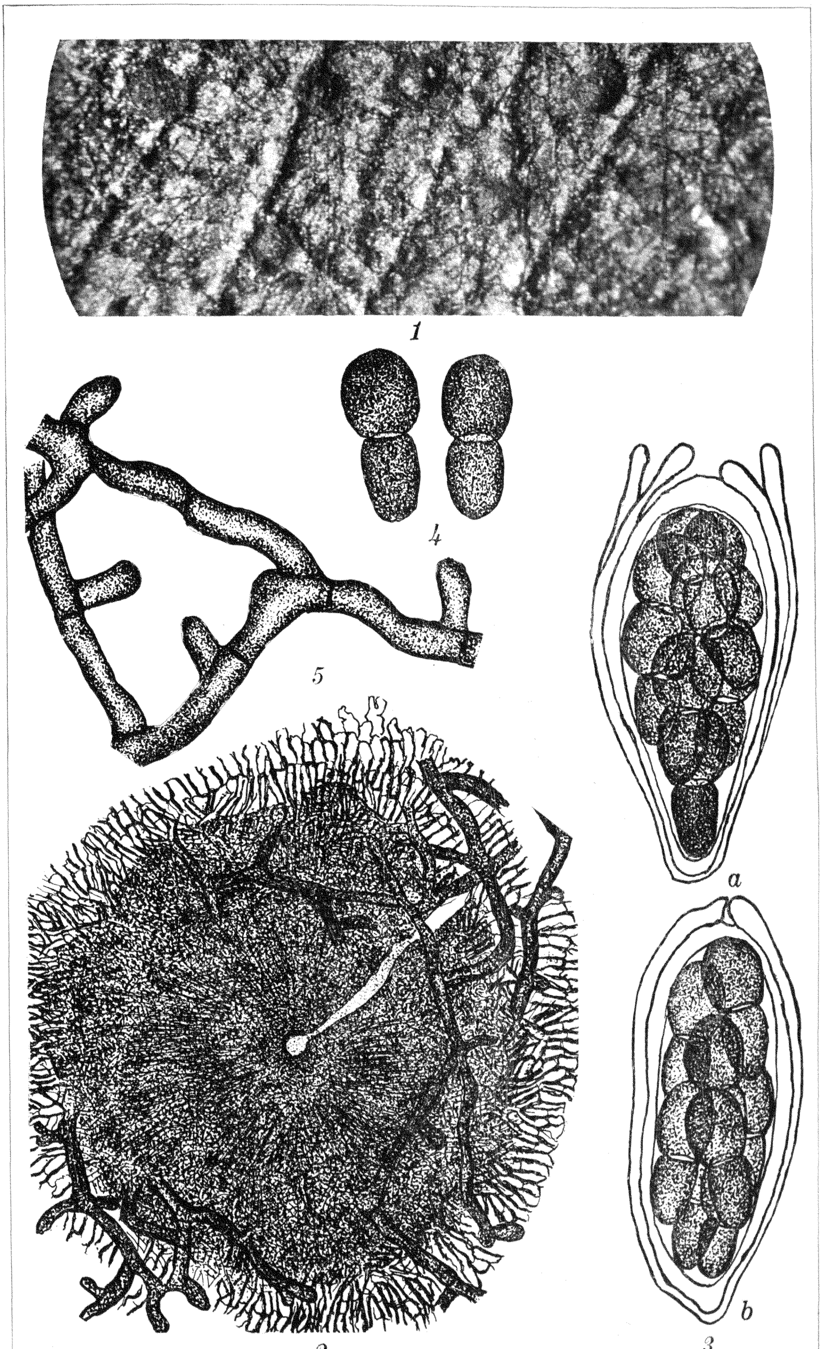

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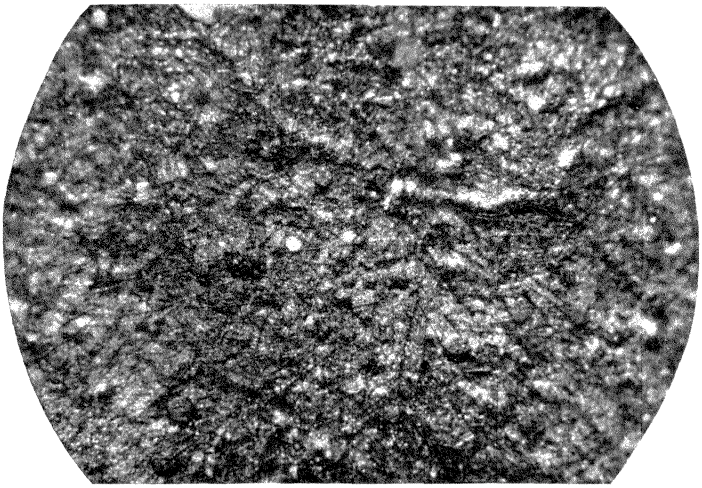

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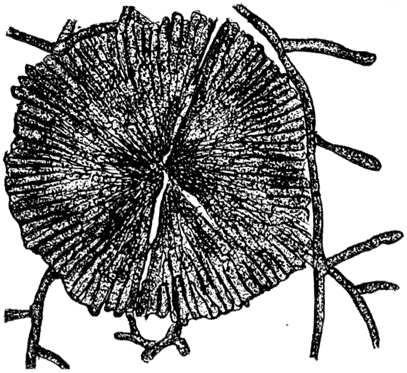

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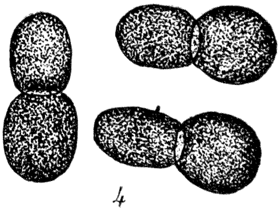

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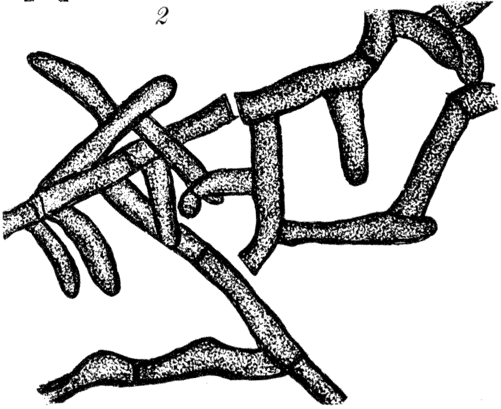

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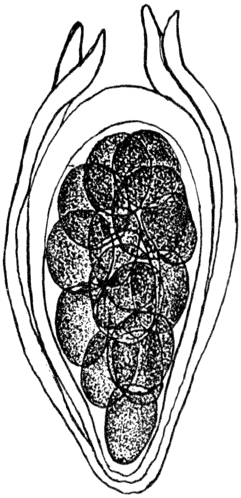

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PLATE 6.

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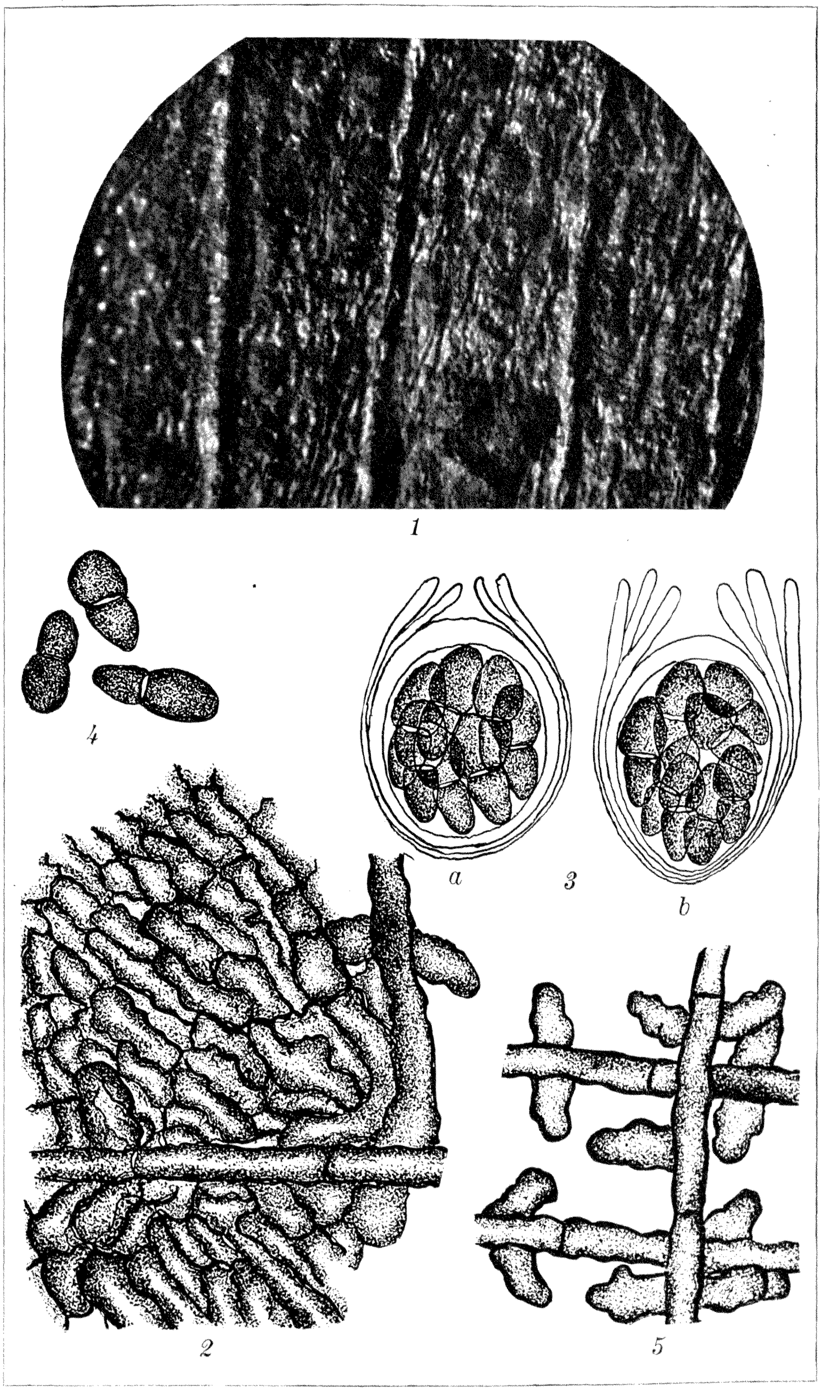

PLATE 7.

UNIV. OF MICH.

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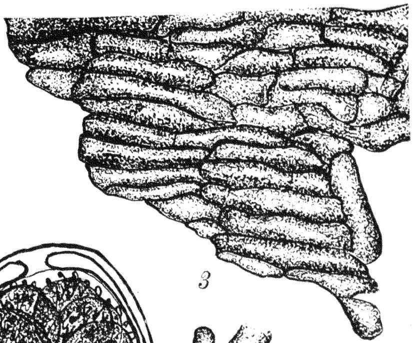

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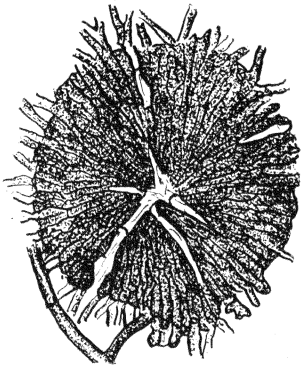

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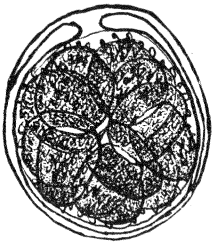

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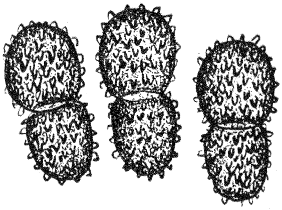

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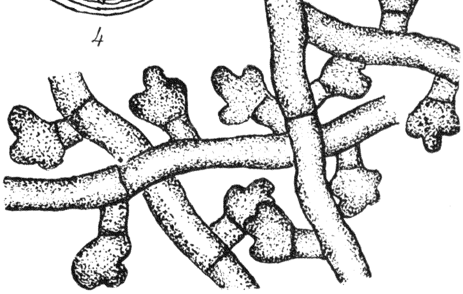

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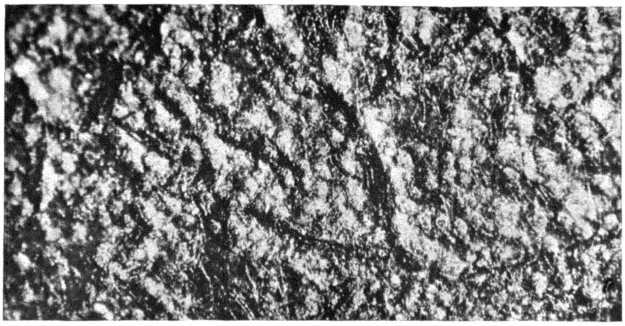

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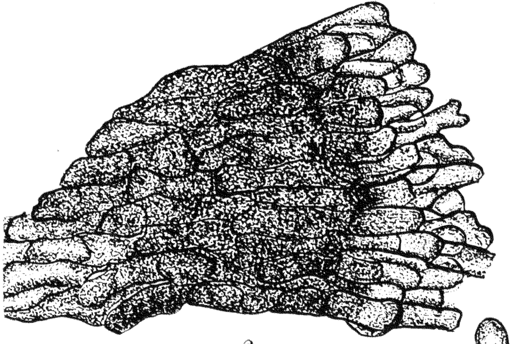

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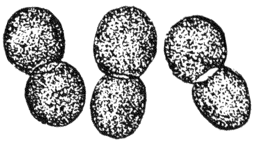

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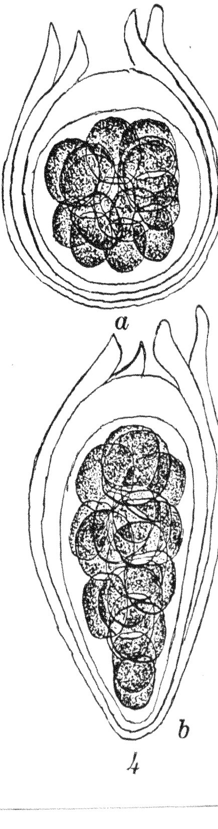

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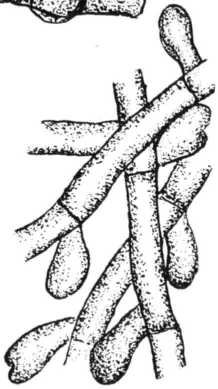

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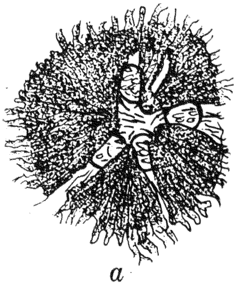

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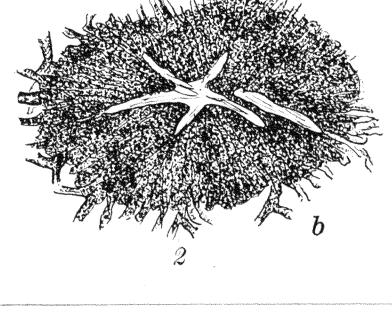

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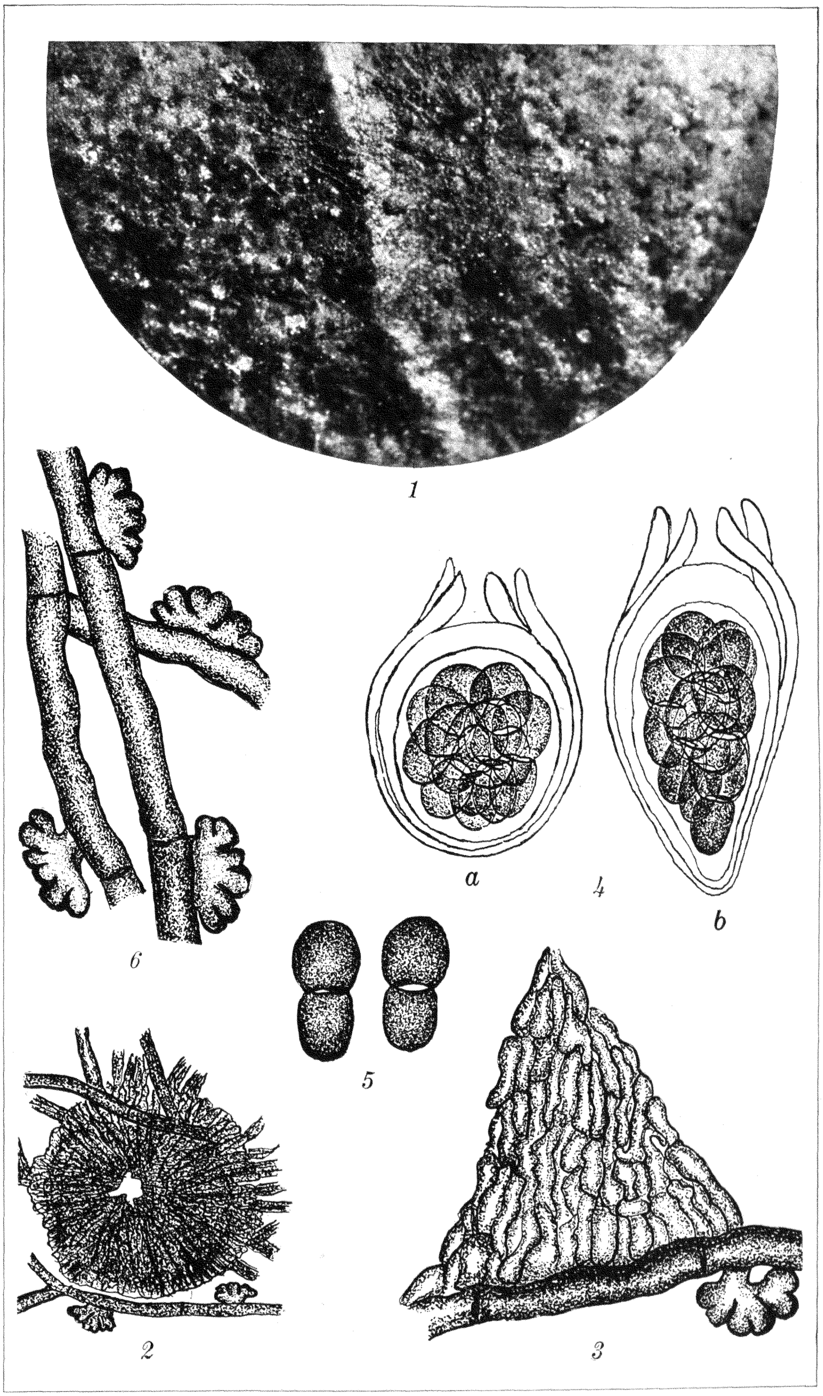

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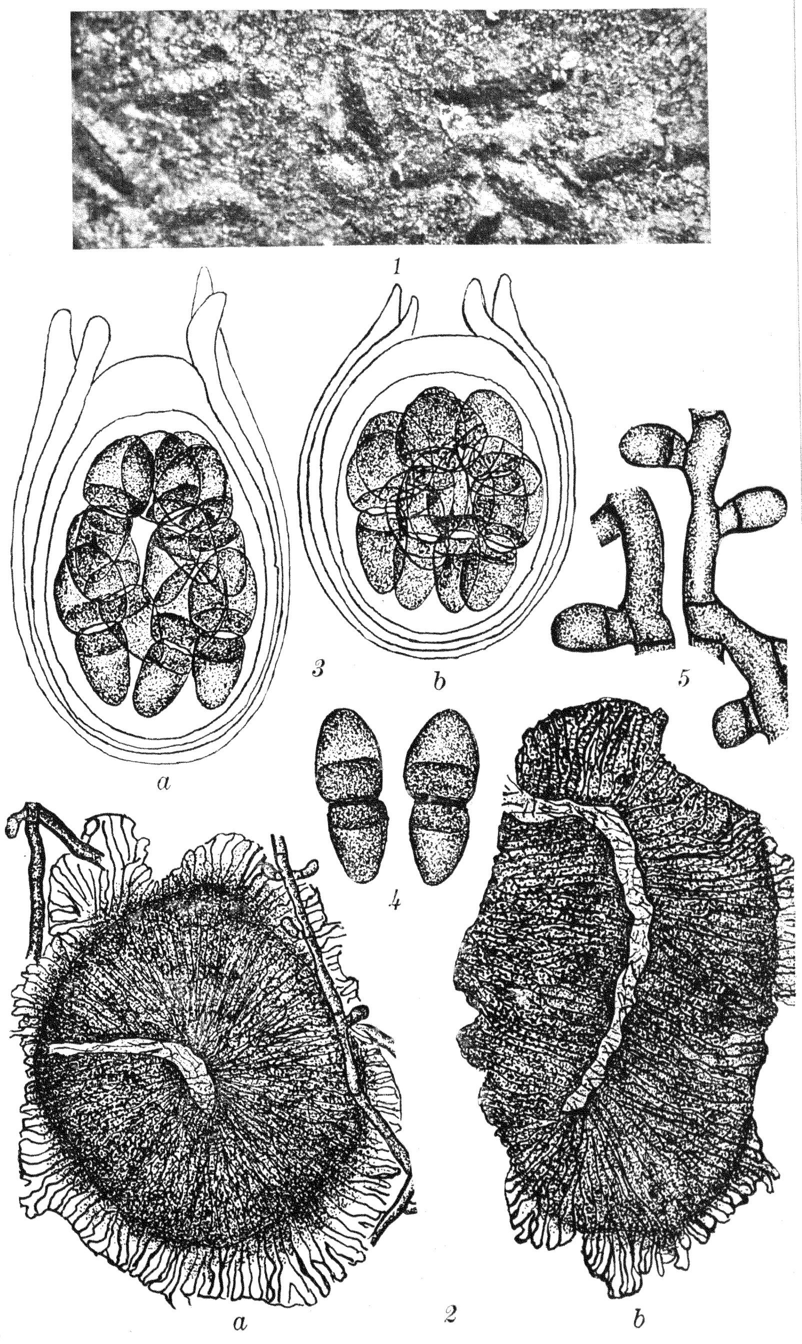

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UNIV. OF MICH.

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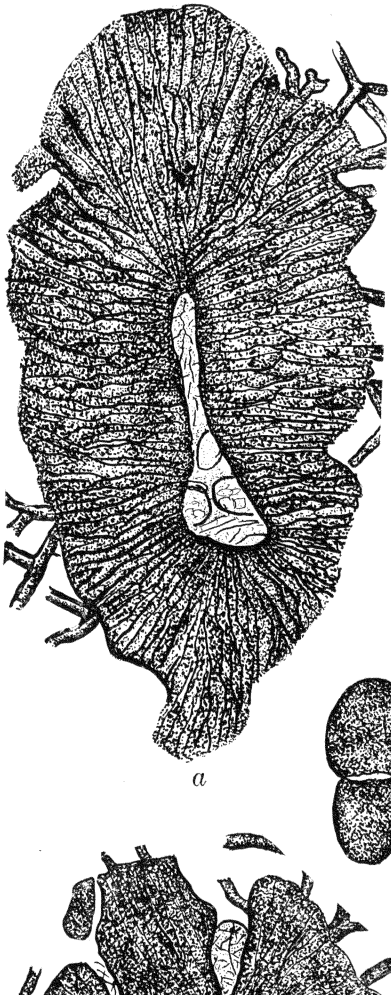

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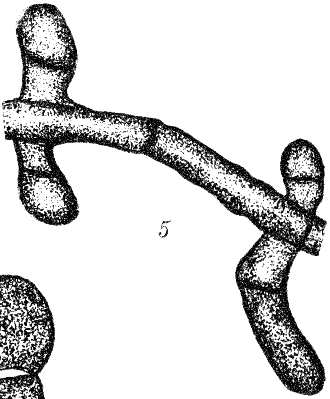

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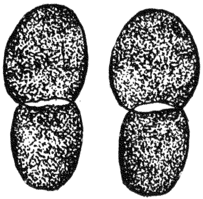

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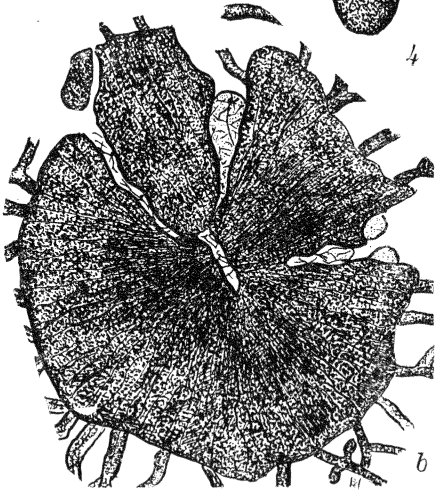

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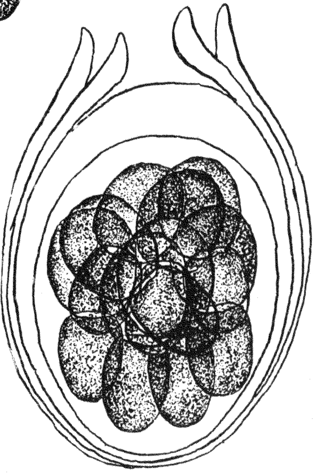

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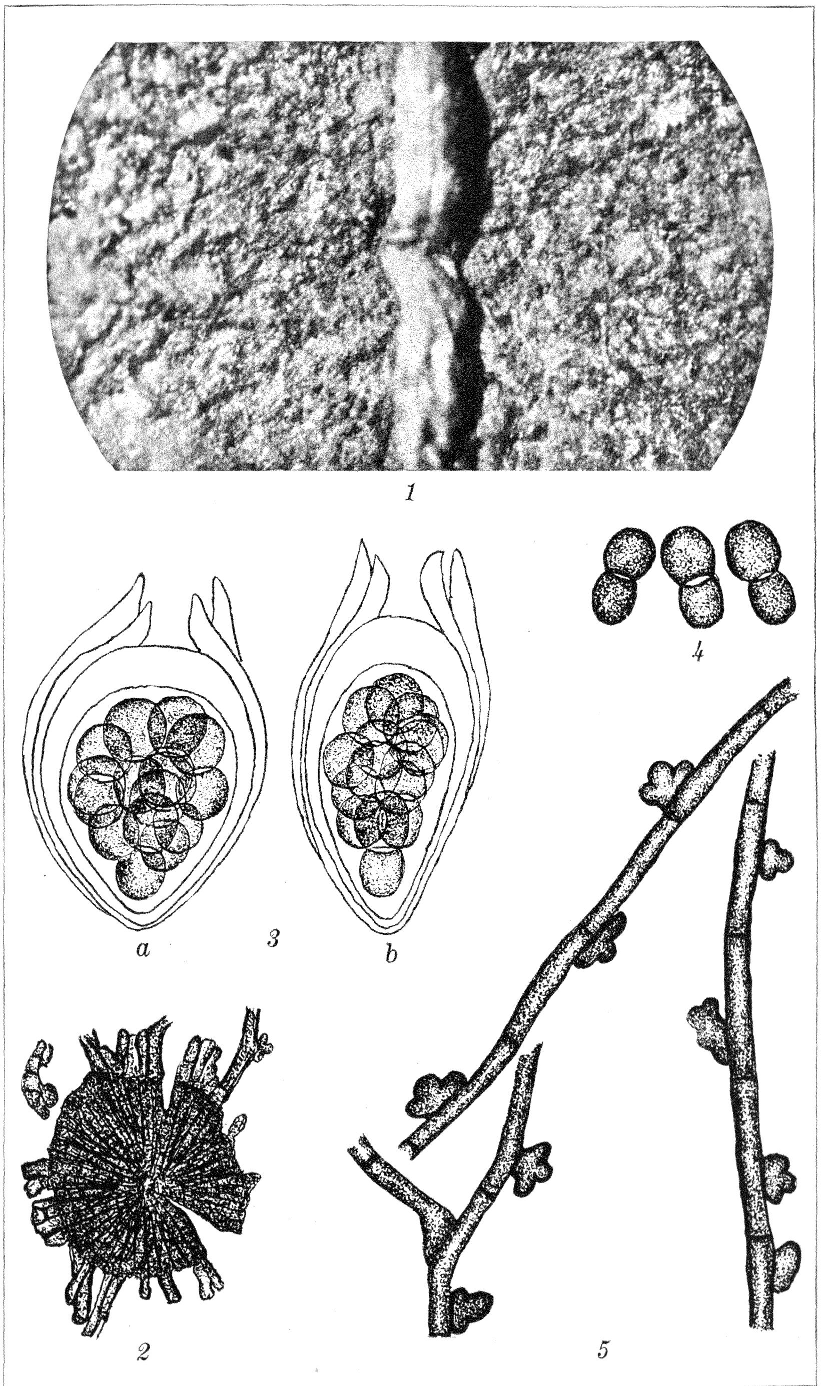

PLATE 13.

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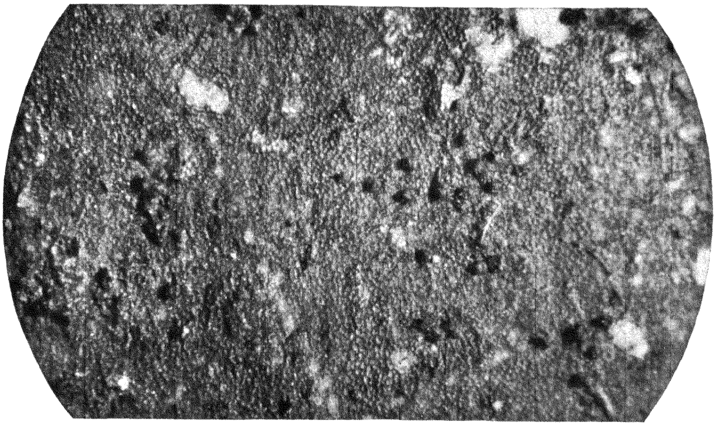

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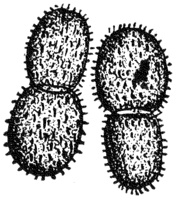

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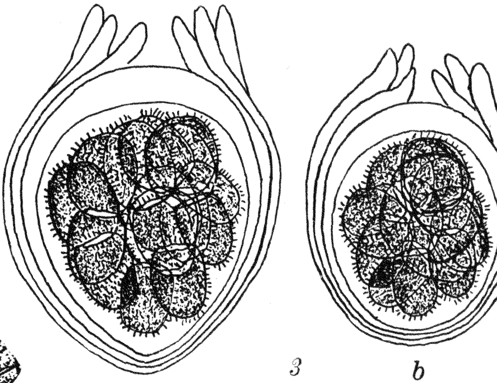

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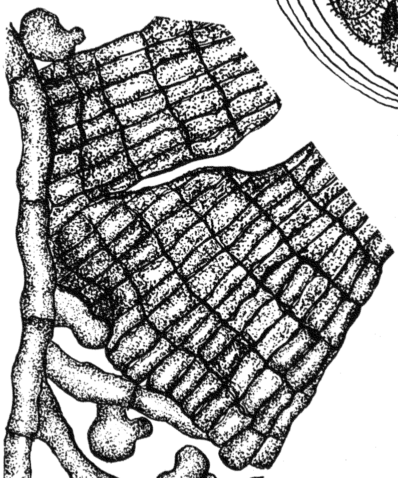

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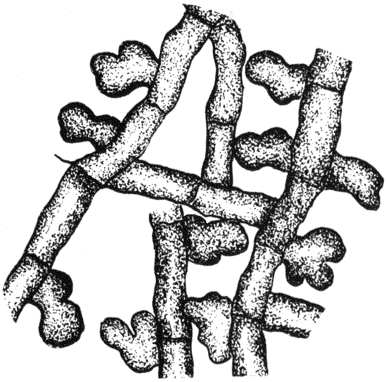

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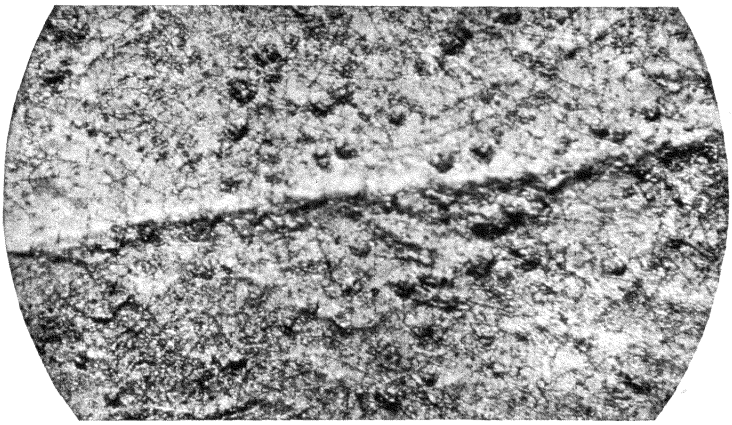
PLATE 14.

UNIV. OF MICH.



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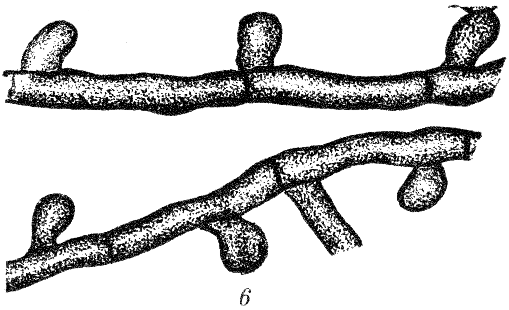

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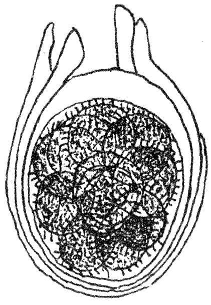

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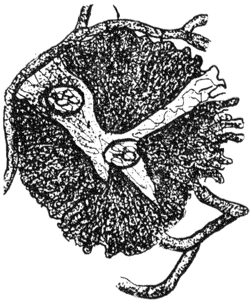

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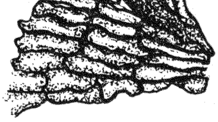

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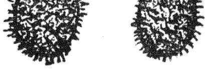

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PLATE 15.

UNIV. OF MICH.

NITROGEN DISTRIBUTION IN THE LEAVES OF PHILIPPINE CAMPHOR TREES

By JOAQUIN MARAÑON

Of the Division of Botany, Bureau of Science, Manila

The partition of the nitrogenous constituents of plant and animal tissues is one of the means employed for the investigation of various kinds of biochemical problems. Primarily, it gives an insight into the composition of the protein which is the major constituent of protoplasm. It serves as an index to ascertain the influence of factors on the nitrogen metabolism of an organism. It is also useful in interpreting the results of the chemical analysis of foodstuffs.

Two years ago, West and Taguibao[1] carried out an investigation on the camphor content of camphor trees growing at Baguio in the Mountain Province of the Philippines. They found that camphor occurs almost entirely in the leaves of Philippine trees and, by distilling the leaves, crystal camphor containing a small amount of oil is usually obtained. They found, however, that when the leaves of a certain few trees were distilled there was obtained only a yellow volatile oil instead of the usual camphor crystals. This volatile oil has a negative rotation and is evidently quite different from the ordinary camphor oil which is dextrorotatory. Since the trees, from which this unusual lævo oil was obtained, were growing promiscuously among the ordinary camphor trees, it would seem unlikely that the production of this lævo oil was due to the ordinary environmental factors.

From a physiological point of view it seemed interesting to compare the nitrogen distribution in leaves from trees giving a lævo oil with that in leaves yielding the usual crystal camphor, and to ascertain if these two kinds of camphor trees (lævo oil and crystals) give different nitrogen partition products.

EXPERIMENTAL PROCEDURE

Collection of material.—The camphor trees selected for this investigation were a portion of those labelled by West and Taguibao for their work on Philippine camphor.

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[1] Philip. Journ. Sci. 41 (1930) 103.

The leaves were collected from freshly cut branches. Care was taken that the collection of samples from the leaves of trees giving lævo oil and from those giving crystal camphor was done on the same day. The trees selected were growing side by side in the same locality. The samples were sorted into young, full-grown, and old leaves showing signs of chlorophyll degradation. These leaves were air-dried and reduced to a fine powder. Moisture determinations for each sample were made by heating the leaves to constant weight at a temperature of 105° C. in order to express the percentage of the nitrogenous constituents on a moisture- and camphor-free basis.

Methods of analysis.—The total nitrogen was determined directly from the air-dried samples of the leaves according to the official Gunning Method, modified to include the nitrogen of nitrates.[2] The insoluble nitrogen was obtained by subtracting the water-soluble nitrogen from the total nitrogen of the leaves. The various forms of nitrogen—such as the water soluble, nitrate, free amino acid, and ammonia—were obtained from the aqueous extract of the leaves in the following way:

A 10-gram sample of the powdered leaves was placed in a bottle containing 500 cubic centimeters of distilled water and shaken in a shaking machine for two hours. After the bottle had been set aside to allow the powder to subside, the clear supernatant liquid was carefully decanted from the sediment. The treatment was repeated twice, with the same amount of distilled water. The combined aqueous liquids were filtered, and the wet powder from the bottle was poured into the filter. The filtered aqueous extract was made to a volume of 2 liters.

Water-soluble nitrogen.—Two 100-cubic-centimeter portions of the aqueous extract were transferred to Kjeldahl digestion flasks and concentrated to about 30 cubic centimeters. The nitrogen in the concentrated solution was determined in accordance with the method suggested by Pucher, Leavenwoth, and Vickery for the total nitrogen of plant extracts in the presence of nitrates.[3]

Nitrate nitrogen.—This was determined in an aliquot portion (150 cubic centimeters) of the aqueous extract, using Devarda's alloy method modified by Whiting, Richmond, and Schoonover.[4]

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[2] Official and tentative methods of analysis of the Assoc. Offic. Agr. Chemists. (Revised to July 4, 1924.)

[3] Industrial and Engineering Chemistry, Analytical Edition 2 No. 2 (1930) 191.

[4] Industrial and Engineering Chemistry 12 No. 10 (1920) 982.

Free amino acid nitrogen.—Two aliquot portions of 50 cubic centimeters of the aqueous extract were evaporated on a water bath to about 10 cubic centimeters and used for the determination according to Van Slyke's method.[5]

Ammonia nitrogen.—This determination was made on an aliquot portion (150 cubic centimeters) of the aqueous extract according to a method which was essentially the same as that described by Longi.[6] In this method, the solution is rendered alkaline with magnesium oxide, a few drops of caprylic alcohol are added to prevent excessive foaming, and the mixture distilled in vacuo at a temperature of 38 to 40° C.

The acid amide, humin, basic, and nonbasic nitrogen of the aqueous extract were determined according to the method of Hausmann as modified by Jodidi.[7]

The nitrogen partition in the leaves after acid hydrolysis was carried out according to Jodidi and Moulton's procedure.[8]

The nitrogen distribution in the water-insoluble portion of the leaves was ascertained by subtracting the different forms of nitrogen obtained in the aqueous extract of the leaves from the corresponding forms of nitrogen determined in the leaves after acid hydrolysis.

DISCUSSION OF RESULTS

The total nitrogen in the leaves of the camphor trees as shown in Table 1 varies according to the age of the leaf. This variation is also observed in the distribution of the different forms of nitrogen as can be seen in Tables 2 to 5. There is, however, no consistent variation in any certain direction.

The old leaves have a higher free amino nitrogen (Tables 2 and 3) but are lower in humin nitrogen (Tables 4 and 5) than either the young or full-grown leaves. The young leaves, on the other hand, have lower ammonia nitrogen than either the full-grown or old leaves (Tables 2 and 3). With respect to other forms of nitrogen, no significant differences can be noted. The exceedingly high percentage of nitrogen from free amino acids in the old leaves may be explained as due to the rapid hydrolysis of the protein so that the amino acids can be translocated to the stem and other growing parts of the plant. According to

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[5] Journ. Biol. Chem. 12 (1912) 277.
[6] Landw. Vers. Stat. 32 (1886) 15.
[7] Journ. Am. Chem. Soc. 42 (1920) 1883.
[8] Journ. Am. Chem. Soc. 41 (1919) 1526.

Combes,[9] before the leaves turn yellow most of the nitrogenous constituents are withdrawn.

A consideration of the entire experimental data shows that, in general, no consistent differences were found in the different forms of nitrogen which occur in the leaves of trees containing a mixture of camphor crystals and in the leaves of those which yield only a **lævo oil.**

TABLE 1.—*Total nitrogen in the leaves of Philippine camphor trees.*

Tree No.	Location.	Kind of leaves.	Plant product from leaves (camphor crystal or lævo oil).	Nitrogen.[a]
				Per cent.
8-F	Near Teacher's Camp	Young	Oil	3.31
8-F	do	Full-grown	do	1.66
8-F	do	Old	do	1.69
8-E	do	Young	Crystal	2.44
8-E	do	Full-grown	do	2.56
8-E	do	Old	do	2.05
19	Near office, Bureau of Forestry	Young	Oil	1.50
19	do	Full-grown	do	1.96
19	do	Old	do	2.18
19-A	do	Young	Crystal	2.72
19-A	do	Full-grown	do	1.45
19-A	do	Old	do	2.07
12-G	Session Road near Military Circle	Full-grown	Oil	1.87
12-D	do	do	Crystal	1.33
11	Forest Nursery, below Ranger's House	Old	Oil	1.37
11-A	do	do	Crystal	1.48

[a] Calculated on moisture- and camphor-free basis.

SUMMARY

1. The total nitrogen and the distribution of its different forms in camphor leaves growing at Baguio, Mountain Province of the Philippines, vary according to the age of the leaf.

2. The old leaves showing signs of chlorophyll degradation have higher free amino acid nitrogen but lower humin nitrogen than either the young or full-grown leaves. On the other hand, the young leaves have lower ammonia nitrogen than either the full-grown or old leaves. Other forms of nitrogen show no significant differences.

3. No consistent differences appear to exist in the forms of nitrogen obtained from leaves of trees containing a mixture of camphor crystals and oil and from the leaves of those yielding only a lævo oil.

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[9] Rev. gen. bot. 38 (1926) 430, 510, 565, 632, and 673.

TABLE 2.—*Nitrogen partition in the leaves of Philippine camphor trees.*
(Percentage based on moisture- and camphor-free basis.)

Tree No.	Kind of leaves.	Plant product from leaves (camphor crystal or lævo oil).	Total nitrogen.	Kind of nitrogen.								
				Water-soluble.	Insoluble.	Nitrate.	Free amino.	Ammonia.	Water-soluble.			
									Acid amide.	Humin.	Basic.	Nonbasic.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
8–F	Young	Oil	3.31	0.45	2.80	0.12	0.07	0.02	0.07	0.05	0.07	0.26
8–F	Full-grown	do	1.66	0.41	1.15	0.18	0.03	0.11	0.04	0.07	0.05	0.25
8–F	Old	do	1.69	0.30	1.39	0.10	0.10	0.07	0.03	0.02	0.03	0.22
8–E	Young	Crystal	2.44	0.29	2.15	0.15	0.06	0.04	0.05	0.03	0.03	0.18
8–E	Full-grown	do	2.56	0.36	2.20	0.11	0.02	0.08	0.03	0.07	0.06	0.20
8–E	Old	do	2.05	0.62	1.43	0.16	0.15	0.15	0.07	0.05	0.08	0.42

TABLE 3.—*Nitrogen partition in the leaves of Philippine camphor trees.*
(Data expressed as percentage of the total nitrogen of the leaves.)

Tree No.	Kind of leaves.	Plant product from leaves (camphor crystal or lævo oil).	Kind of nitrogen.								
			Water-soluble.	Insoluble.	Nitrate.	Free amino.	Ammonia.	Water-soluble.			
								Acid amide.	Humin.	Basic.	Nonbasic.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
8-F	Young	Oil	13.59	86.41	3.62	2.11	0.60	2.11	1.51	2.11	7.85
8-F	Full-grown	do	24.69	75.31	10.84	1.81	6.62	2.41	4.22	3.01	15.06
8-F	Old	do	17.75	82.25	5.96	5.91	4.14	1.78	1.18	1.78	13.01
8-E	Young	Crystal	11.88	88.12	6.14	2.45	1.63	2.04	1.22	1.22	7.14
8-E	Full-grown	do	14.06	85.94	4.29	0.78	3.11	1.17	2.73	2.34	7.82
8-E	Old	do	30.24	69.76	7.81	7.31	7.31	3.41	2.43	3.90	20.48

TABLE 4.—*Nitrogen partition in the leaves of Philippine camphor trees, after acid hydrolysis.*

Tree No.	Kind of leaves.	Plant product from leaves (camphor crystal or lævo oil).	Kind of nitrogen.							
			Acid amide in—		Humin in—		Basic in—		Nonbasic in—	
			Leaves.[a]	Total nitrogen.[b]	Leaves.[a]	Total nitrogen.[b]	Leaves.[a]	Total nitrogen.[b]	Leaves.[a]	Total nitrogen.[b]
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
8–F	Young	Oil	0.38	11.42	0.22	6.74	0.29	8.67	2.42	73.17
8–F	Full-grown	do	0.28	16.80	0.28	16.68	0.24	14.52	0.86	51.98
8–F	Old	do	0.22	12.72	0.09	5.38	0.16	9.47	1.22	72.42
8–E	Young	Crystal	0.18	7.54	0.28	11.43	0.30	12.25	1.68	68.77
8–E	Full-grown	do	0.18	7.15	0.31	12.07	0.25	9.84	1.82	70.94
8–E	Old	do	0.24	11.75	0.18	8.68	0.23	11.07	1.40	68.48

[a] Percentage calculated on moisture- and camphor-free basis.

[b] Percentage based on the total nitrogen in the leaves.

Table 5.—*Nitrogen partition in the water-insoluble portion of the leaves of Philippine camphor trees.*

Tree No.	Kind of leaves.	Plant product from leaves (camphor crystal or lævo oil).	Kind of nitrogen.							
			Acid amide in—		Humin in—		Basic in—		Nonbasic in—	
			Leaves.[a]	Total nitrogen.[b]	Leaves.[a]	Total nitrogen.[b]	Leaves.[a]	Total nitrogen.[b]	Leaves.[a]	Total nitrogen.[b]
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
8–F	Young	Oil	0.31	9.31	0.17	5.23	0.22	6.56	2.16	65.32
8–F	Full-grown	do	0.24	14.39	0.21	12.46	0.19	11.51	0.61	36.92
8–F	Old	do	0.19	10.94	0.07	4.20	0.13	7.69	1.00	59.41
8–E	Young	Crystal	0.13	5.50	0.25	10.21	0.27	11.03	1.46	61.63
8–E	Full-grown	do	0.15	5.96	0.24	9.34	0.19	7.50	1.62	63.12
8–E	Old	do	0.17	8.34	0.13	6.25	0.15	7.17	0.98	48.00

[a] Percentage calculated on moisture- and camphor-free basis.

[b] Percentage based on the total nitrogen in the leaves.

PSEUDOMYCETOMA IN THE PHILIPPINES, WITH REPORT OF ONE CASE

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FOUR PLATES

Previous to the acceptance of Chalmers and Archibald's classification, the term mycetoma was applied to all granulomatous conditions, often localized in the foot, caused by fungi, but without much consideration of the type of the causative microörganisms.

Carter(1) in 1860 studied cases of mycetoma of the foot, a disease prevalent in the town of Madura and recognized first the fungous nature of the infection.

Chalmers and Archibald(2) considered later as mycetomas the actinomycoses and the maduromycoses. The maduromycoses, although clinically similar to the actinomycoses, differ in respect to the microscopic appearance of their causative fungi.

The definition given of mycetoma is as follows: Mycetoma includes all growth and granulations in any of the tissues of men or animals which are caused by fungi belonging to different genera and species, which produce bodies or granules called grains of various dimensions, shape and colors composed of hyphæ and sometimes clamydospores which are found either embedded in the pathological tissues or escaping freely in the discharge therefrom.

In 1918 Chalmers and Archibald(3) described a condition of the foot which resembles more or less Madura foot in external characters, differing only in the absence of typical grains in the pus or tissues. As this condition appears to be of importance from a diagnostic point of view the disease was designated under the new name of pseudomycetoma.

The term pseudomycetoma was first used by Castellani(4) to indicate a peculiar condition of the foot in tertiary yaws. According to Breil, however, pseudomycetoma must be considered as a clinical entity separated from yaws. Cases of pseudomycetoma have been registered according to this author in New Guinea under different native names and the disease resembles typical Madura foot without the presence of the characteristic grains in the pus.

As a contribution to the knowledge of this important group of mycosis and with the purpose of interesting tropical practitioners in the search for cases of this nature, I report a case registered in a native of the Philippines. The lesion of the foot resembles a typical Madura foot, as clearly seen by the picture. I consider this case a pseudomycetoma since the typical grains could not be demonstrated either in the pus in the several examinations or in the histological preparation of tissues removed in the biopsy. The bacteriological smears and cultures from the pus of the sinuses revealed, in the absence of other bacteria, the presence of a fungus belonging to the group of *Nocardia* or *Streptothrix*. The strain isolated was pathogenic to guinea pigs and monkeys, and when injected into a monkey's foot produced a swelling that was quickly followed by the formation of a suppurative lesion.

It is worth while to mention here that in reviewing the medical literature in the Philippines, our case seems to be the first one reported of this special type of mycetoma, since the only case studied in 1907 by Musgrave and Clegg was considered a true mycetoma with typical grains of the ochroid variety. At the same time it is interesting to say that the fungus isolated in our case resembles in many respects the organism described by Musgrave and Clegg under the name *Streptothrix freeri*. Very probably this particular strain is predominating in this country.

HISTORY

E. O., 28 years old, male, Filipino, married, born in San Narciso, Pangasinan Province, Philippine Islands, complained of painless enlargements of the left ankle with multiple nodules on the same. Family history negative. Previous history unimportant, except for this affection of the foot.

The present illness is of nine years duration, following a misstep after which the patient noticed a small elongated hard mass (1 by 3 centimeters) below the external malleolus of the left ankle. The mass was nontender, and movable with the skin adherent to it. This did not increase in size until four years ago, when the external surface of the left foot was caught by one of the teeth of a harrow, wounding the part. Following this, the mass at the external malleolus of the left ankle enlarged rather rapidly, covering the entire malleolus. The wound suppurated and healed in a week's time, only to be followed by a small elongated mass underneath the skin beside the scar. The mass then softened and later burst, giving out pus and dead blood. Around the first mass several small elongated nodules developed, and thus the swelling and induration of the part spread peripherally outward. At times several hard nodules developed and ruptured, and at other times only one developed. The time of rupturing varied from a day to a week. This process continued until nearly the whole left foot and part of the ankle were involved but respecting so far the plantar region. There was also, besides the induration and the nodules, a dark discoloration of the skin.

Physical examination.—Nothing of importance except the localized lesion. The left ankle including most of the left foot is markedly enlarged, with multiple nodules on the surface. The swelling is slightly tender on very deep pressure. There are several nodular swellings all over the ankle and medial surface of the foot except on the plantar region, some hard and some fluctuating of about the size of mongo beans, exuding a thin seropurulent discharge. Some of these nodules are healed and scarred, others are covered by hyperkeratotic skin. No granules can be seen in the pus from these nodules. There is hyperpigmentation of the skin. The leg is enlarged up to the lower half but atrophied at the upper half.

Laboratory.—Blood examination gave the following:

Red blood cells		3,800,000
Hemoglobin (Talquist method), per cent		75
Leucocyte count		8,800
Differential:		
Neutrophils	75	
Small lymphocytes	17	
Large lymphocytes	4	
Large mononuclears	7	
Eosinophils	0	
	100	

Blood pressure, systolic, 148; diastolic, 52. Urine and fæces, nothing important. X-ray examination, slight changes of osteoperiostitis in lower end of left fibula. Wassermann blood test, negative. Temperature, afebrile throughout stay in ward.

Local antiseptic treatments were applied to the lesion, and potassium iodide was given per orem without improvement. Amputation of the foot was proposed, but the patient refused the operation. After almost two weeks stay in the hospital a bacteriological culture from the lesion was made, the specimen being taken from a closed nodule. The material was planted on blood hormone agar slant tubes and incubated at room and incubator temperatures. On the fourth day after inoculation a pure growth of a streptothrix organism was obtained from the tubes and no other bacterial colony was present. The morphological, tinctorial, and biological characteristics of this organism are as follows:

Morphology.—Smears from young cultures show numerous filamentous branching forms. The filaments have a definite wall and some of the hyphæ show slight swollen ends. The organism stains well with ordinary aniline dyes and in these preparations the filaments show in the interior few coccoid and bacillary forms of various length. Branching occurs as lateral hyphæ from the segmented portions. With the Ziehl-Neelson acid-fast stain method, the bacillary forms in young cultures assume the bright red color of tubercle bacilli but the filaments are as a rule non-acid fast; a few of them, however, are slightly stained pinkish. In old cultures, at least 7 days old, more numerous and deeply stained acid-fast filaments are found, also numerous coccoid and bacillary acid-fast forms. With the Gablet's acid-fast stain method more uniform and intensively acid-fast forms are obtained.

Cultures.—The streptothrix was cultivated without difficulty from the nodules and sinuses of the affected foot on hormone blood agar slant tubes. Visible growth appeared on the second day, and typical and good growth was obtained on the fourth day. The isolated colonies on this medium were dry, rounded, somewhat smaller than the staphylococcus colony, with folded edges and slightly umbilicated centers, simulating small rosettes. The colony was pale yellowish, turning yellowish pink with age. Later, more colonies developed and a heaped up and wrinkled yellowish pink growth was obtained. No hæmolysis was noticed, but the medium became darker with age.

Transplants were made to peptone broth, litmus milk, potato, Loeffler's blood serum, ordinary agar, glucose agar, glycerin agar, glycerin broth, Saboraud's medium, and various carbohydrates.

A profuse growth appeared in a few days in certain of these media, in others the development was much slower. Glycerin agar, glucose agar, and hormone blood agar are considered the best media. The growth was slightly more rapid at incubator temperature (37° C.) than at room temperature (28° C.).

Peptone water.—Good growth was obtained after two or three days only on the surface of the medium, as small, delicate, pale yellowish, flat particles slightly umbilicated in the center which became confluent and adherent to the sides of the tubes. The medium did not become cloudy. The so-called puffball growth was not observed.

Litmus milk.—Moderate growth was obtained after two or three days on the surface of the medium, of the same character as in peptone broth. No change of color occurred in the medium, but in time the upper part of the culture, below the surface growth, became darker blue. Milk was not coagulated.

Potato.—Very scanty growth was obtained in the medium even after four days incubation, in the form of minute yellowish white colonies.

Loeffler's blood serum.—Growth appeared after three days in the form of minute, dry, confluent, yellowish colonies, which later became yellowish pink. There was no evidence of liquefaction.

Agar —1 per cent.—Good growth was obtained after three days as a powdery, confluent, whitish yellow growth.

Agar +1 per cent.—Scanty growth was obtained after three days as small, dry, yellowish colonies with slightly umbilicated center.

Glucose agar.—In slant tubes good growth was obtained after two or three days as confluent, minute, dry, yellowish colonies. In a week a heavy heaped up growth was observed with pronounced pinkish coloration. In stab tubes a wrinkled heaped up yellowish pink growth was obtained on the surface, and no growth on the depth of the agar.

Glycerin agar.—A confluent, heavy, heaped up growth was obtained in two or three days. Colonies were small, dry, rounded, umbilicated, and whitish in color. Later colonies turned yellowish and further yellowish pink.

Carbohydrates.—Subplants on lactose, dextrose, maltose, saccharose, and mannite broth with Andrade's indicator, showed surface growth the same as in peptone. Neither acid nor gas fermentation was noticed on prolonged incubation.

Saboraud's medium.—Good growth was obtained at room temperature in the form of a powdery whitish growth which did not become pinkish.

Pathogenicity.—A monkey was injected with 2 cubic centimeters of a suspension of our organism in sterile saline; the injection was made in the tissues of the right foot, the foot became inflamed and an ulcer developed after three days which discharged a thick purulent material. The streptothrix was recovered in the cultures from the lesion. A guinea pig was injected intraperitoneally with thick streptothrix suspension in sterile saline. The animal was killed thirteen days after injection. Autopsy revealed very minute necrotic yellowish nodules in the peritoneal surface, omentum, and liver. Cultures from different nodules yielded pure growth of streptothrix.

Histological sections from liver, stained with hæmatoxylin eosin, showed small rounded necrotic areas containing polymorphonuclear leucocytes with the fungus at the center. The organisms in section stained well and resembled in appearance the granule of actinomyces. At the periphery the radiating mycelial threads could be seen, but the ray formation and the club appearance were much less noticeable.

SUMMARY

The disease known as mycetoma, or Madura foot, was diagnosed formerly on clinical grounds, without much regard to the type of the infecting fungus. The finding of the typical grain in the pus or tissues is considered the most important in the diagnosis. Three varieties of grains were recognized; namely, the black, the red, and the ochroid or yellow, the last being the commonest found.

Chalmers and Archibald(2) introduced more recently the clinical terms pseudomycetoma and paramycetoma to differentiate from true mycetoma conditions of the foot clinically similar to Madura foot, and also certain sarcomalike and epitheliomalike tumors, caused by fungi in which the characteristic grains cannot be easily demonstrated, probably due to their reduced numbers or absence.

From the bacteriological point of view, there is difference of opinion in regard to the etiology of Madura foot. Some authors believe that the disease is caused by actinomyces, others by different types of streptothrix organisms. The first contention, however, is not well supported in the few cases reported in the literature.

Kanthack(5) in 1893 studied three cases of the black type and twelve of the yellow. He concluded that both were due to the same fungus and actinomyces.

Boyce and Surveyor(6) in 1894, while acknowledging the similarity of the organism found in these two varieties of mycetoma and in actinomycosis, believed that the two forms differ distinctly in etiology.

Vincent(7) in 1894 reported a case of the ochroid variety and cultivated a streptothrix from the lesions. Vincent considered his microörganism different from actinomyces not only morphologically but also in cultures and in inoculation experiments. This microörganism was named *Streptothrix maduræ.*

Wright(8) in 1894 succeeded in cultivating a new variety of streptothrix from a case of mycetoma of the black type. The work of Vincent and Wright seem to be carefully carried out and their conclusions appear to be sound.

Foulerton and Jones in 1902 (cited by Musgrave and Clegg) published an exhaustive article dealing with streptotricosis in general. The authors in discussing mycetoma considered *Streptothrix maduræ* Vincent the cause of the ochroid variety and Wright's streptothrix the cause of the black type.

McLeod(9) believes that Vincent's streptothrix is the etiologic agent of the yellow variety of mycetoma, and that this organism is allied to but differs from the actinomycosis. The black species of Madura foot, he thinks, is due to a degenerated form of the same fungus.

One of the most valuable investigations regarding the etiology of mycetoma is that of Musgrave and Clegg(10) in 1907. These authors reported a typical case of Madura foot of the ochroid variety of three years duration in a Filipino woman, 30 years old. A new variety of streptothrix was isolated from the lesions and the microörganism was named *Streptothrix freeri.* With this organism they performed inoculated experiments on forty monkeys, guinea pigs, rabbits, dogs, and pigeons, and in three instances typical examples of Madura foot developed in monkeys after the injection of cultures in the tissues of the foot. These investigators believed at the same time that actinomycosis has been mistaken for Madura foot, both of the ochroid and black types in some of the reported cases, and concluded that it is probable that all types of mycetoma are due to streptothrix infection. Whether all forms are caused by the same organism or whether more than one species plays a part in the disease can not be stated positively.

Quite recently, in 1916, Clegg and Hobdy(11) reported another case of Madura foot, also of the ochroid variety, in a native woman of Hawaii, of five years duration. The microörganism isolated is a streptothrix culturally resembling *Streptothrix maduræ* of Vincent.

Our case is interesting both from the clinical and bacteriological standpoint. Clinically, the lesion resembles typical Madura foot, but the characteristic grains could not be demonstrated in the pus of the sinuses and in the histological sections of the biopsy performed. Bacteriologically, the fungus isolated is an acid-fast, pathogenic, branching streptothrix differing in these peculiar features from Wright's streptothrix isolated in the United States from a case of Madura foot of the black type, and from Vincent's and Clegg and Hobdy's streptothrix isolated respectively in India and Hawaii from cases of the ochroid variety. Our organism resembles in acid-fast properties, pathogenicity, and other biological features the fungus described by Musgrave and Clegg as *Streptothrix freeri*, isolated from a case of Madura foot of the ochroid type which occurred also in a native of the Philippines.

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CHARACTERISTICS OF STREPTOTHRIX AS REPORTED BY VARIOUS AUTHORS

STREPTOTHRIX OF WRIGHT (UNITED STATES)

Morphology.—Long branching filaments, 3 to 8 microns in diameter. In young forms delicate transverse septa are present. In older forms there may be swelling at these points and the hyphæ may appear as a string of oval-ended plump segments. The filaments have a definite wall, and in the interior granules or pale areas may be seen. The branching occurs by the formation of lateral outgrowth of buds. No spore bearer organisms were observed.

Acid-fast properties.—Not acid fast.

Peptone broth.—Growth always proceeds from the planted material whether grain or fragments of mycelium in the form of fine radiating filaments and soon produces a puffball appearance. Eventually the whole area of fluid is filled with radiating mycelium and a definite mycelial layer is formed on the surface. The medium acquires a coffee-brown color.

Potato.—It forms a dense widely spreading coherent membrane or layer of velvety surface, pale brown in color throughout its central portion and white at its peripheral portion. A marked feature is the appearance of small spherical globules or droplets of dark coffee-colored fluid on the surface of this layer. The potato takes a dark brown color and becomes moist.

Glucose agar.—The growth appears as a meshwork of widely spreading filaments of a grayish color on the surface of medium. In old cultures black sclerotia are found as in potato infusion. In stab cultures growth appears only on the surface.

Pathogenicity.—No results were obtained from the inoculation of animals with the original granules or with cultures.

STREPTOTHRIX OF VINCENT (INDIA). DESCRIPTION OF MUSGRAVE AND CLEGG AND OF VINCENT AND FOULERTON

Morphology.—Long thin filaments with true branching: no club forms. These hyphæ may or may not be radially placed at the periphery of the granule. (Musgrave and Clegg.)

Acid-fast properties.—Cultures stained by Ziehl-Neelsen method showed no acid-fast portions; Gram positive with irregular staining. (Musgrave and Clegg.)

Peptone broth.—Growth appears as opaque white globular, more or less cohering colonies at bottom of tube; surface growth rare. No pigmentation of medium. (Vincent and Foulerton.)

Alkaline-litmus milk.—Growth occurs. No obvious change happens in the milk until after twenty days incubation, the medium then becomes pink and after four weeks begins to clear. (Vincent and Foulerton.)

Potato.—Growth appears after three days as small pinkish white colonies, which later develop a dark pink round granular growth. (Musgrave and Clegg.)

Loeffler's blood serum.—Growth slow and scanty. No liquefaction or pigmentation of medium. (Vincent and Foulerton.)

Glycerin agar.—Growth appears after five days as small, pinkish granules and later assumes a dark pink color. (Musgrave and Clegg.)

Resistant to heat, drying; relative growth to temperature; thermal death point.—Sporulating cultures resist an exposure to 45° C. for thirty minutes but are killed by exposure to 60° C. for the same period. (Vincent and Foulerton.)

Pathogenicity.—Inoculation of cats, rabbits, guinea pigs, and mice produced nothing more than a small nodule at the site of inoculation and these disappeared. (Vincent.)

STREPTOTHRIX MUSGRAVE AND CLEGG (PHILIPPINE ISLANDS)

Morphology.—Long branching filaments 2 to 7 millimeters in diameter. Transverse segments are shown of various lengths from coccoid to 10 µ length. Branching occurs as lateral hyphæ developing from the segments. The filaments have a definite wall. Spores have not been observed. Coccoid and clublike forms present in certain media.

Acid-fast properties.—Many acid-fast portions in cultures from 5 days to 2 months old (Ziehl-Neelsen method).

Peptone broth.—Growth occurs after three days, as flat particles on the surface of the medium. These produce in time a delicate pink color and when the tube is shaken they adhere to its sides. As the growth proceeds a granular mass collects at the bottom of the tube. This mass is more or less coherent. Medium does not become cloudy but in time becomes darkened.

Alkaline litmus milk.—Growth appears after three days on surface of medium, as flat drying appearing particles. These later become confluent, forming a heaped up pinkish yellow mass. No reaction occurs in the medium until after the second week, when the color gradually fades but does not become red. This decolorization begins at the bottom. Milk is not coagulated.

Potato.—Growth appears as small pinkish colonies, later raised and becoming confluent. After a few days the growth assumes a heaped up appearance resembling a mass of yellow curls. Medium becomes moist and dark.

Loeffler's blood serum.—Growth appears, after three days, smooth and delicate pink. Growth does not change the character of the medium after three weeks incubation.

Glucose agar.—Growth appears after three days; later becomes luxuriant with a heaped up and wrinkled appearance. The center becomes pinkish yellow with a gradual elimination to a delicate pink and to a white periphery. Stab cultures show only surface growth, with the same pigment characteristics.

Glycerin agar.—Grows well, appearing after three days as raised heaped up moist growth; produces a yellow pigment in center with a pale periphery.

Resistant to heat, drying; relative growth to temperature; thermal death point.—Is killed by exposure to 70° C. for fifteen minutes.

Pathogenicity.—Intraperitoneal inoculations of guinea pigs, monkeys, and dogs with material from lesions and from cultures in nearly every case produced processes resulting in death after two weeks. Rabbits and pigeons were not affected other than by the production of small nodules at site of inoculations in subcutaneous injection; these soon underwent resolution and healed. No progressive lesions were produced by subcutaneous inoculations. In monkeys inoculated in the foot with cultures extensive lesions were produced anatomically resembling Madura foot. Pure cultures were obtained in every instance from experimental lesions.

STREPTOTHRIX C. MONSERRAT (PHILIPPINE ISLANDS)

Morphology.—Smears from young cultures show numerous filamentous branching forms; some of the hyphæ are slightly swelled at the ends.

Filaments have definite wall and in stain preparations show in the interior few coccoid and bacillary forms of various lengths. Branching occurs as lateral hyphæ from the segmented portions.

Acid-fast properties.—In young cultures the bacillary forms are acid fast but filaments as a rule are non-acid fast. In cultures 7 days old more acid-fast filaments are found and numerous bacillary and coccoid acid-fast forms. With Gabbet's stain, acid-fast forms are more deeply and uniformly stained.

Peptone broth.—Good growth obtained after two to three days on the surface of the medium in the form of small, rounded, delicate, flat particles slightly umbilicated in the center which in time become confluent, forming a heaped up whitish yellow pellicle. On being shaken these particles adhere to the side of the tube. The medium does not become cloudy. The puffball growth was not obtained.

Alkaline litmus milk.—Moderate growth is also obtained after two to three days on the surface of the medium as small, rounded, flat particles which become confluent, the same as in peptone broth. No change of color occurs in the medium, but in time the upper part of the medium below the surface growth becomes deeper blue. Milk is not coagulated.

Potato.—Scanty growth is obtained after four days in the form of minute yellowish, white colonies.

Loeffler's blood serum.—Growth appears after three days in the form of minute, confluent, yellowish colonies, which later become slightly pink. No evidence of liquefaction.

Glucose agar.—Glucose agar slant growth is obtained after two or three days in the form of confluent, minute, yellowish colonies. In a week a heavy heaped up growth is obtained with a pronounced pinkish coloration. In stab tubes growth is obtained only on the surface and not in the depth of the agar.

Glycerin agar.—Confluent heaped up growth, obtained after two to three days, consists of rounded, slightly umbilicated, whitish colonies, which later becomes yellowish and further yellowish pink.

Pathogenicity.—A monkey was injected in the tissues of the foot. The foot became inflamed and an ulcer developed after three days which discharged thick purulent material. The streptothrix was recovered from the lesion. A guinea pig was injected intraperitoneally and was killed thirteen days after inoculation. Autopsy showed minute necrotic nodules on the peritoneal surface, omentum, and liver. Pure streptothrix culture was recovered from the lesions.

STREPTOTHRIX CLEGG AND HOBDY (HAWAII)

Morphology.—Long, thin, branching filaments. Spore-bearing organisms were not observed.

Acid-fast properties.—Not acid fast.

Peptone broth.—Growth appears as opaque white colonies at the bottom of the tubes, more or less coherent. The so-called puffball growth was not observed. On shaking the tube numerous flat flaky particles adhere to the sides. The microörganism grows as long, thin, branching filaments. The medium remains clear.

Alkaline litmus milk.—Nothing recorded.

Potato.—Nothing recorded.

Loeffler's blood serum.—Nothing recorded.

Glucose agar.—Growth was luxuriant after six days with heaped up mealy appearance. Old cultures developed a rich cream color. Bacillary and coccoid forms did not occur in this medium.

Glycerin agar.—Growth similar to that on maltose and glucose agar.

Resistant to heat, drying; relative growth to temperature; thermal death point.—Nothing recorded.

Pathogenicity.—Not pathogenic for guinea pigs, rabbits, or monkeys.

ILLUSTRATIONS

PLATE 1

FIG. 1. The patient's foot, markedly enlarged, with multiple nodules on the surface containing seropurulent discharge.

2. Smear from an old culture stained by Gabbet's acid-fast stain method, shows filamentous branching acid-fast forms with bacillary and coccoid forms inside of hyphæ.

PLATE 2

FIG. 1. Section of a liver nodule in a guinea pig injected intraperitoneally with our streptothrix, shows a necrotic area with polynuclear infiltration and the fungus at the center. (Hæmatoxylin eosin stain; high power.)

2. Section from the liver of a monkey injected intraperitoneally with our streptothrix. High-power view of a necrotic nodule with the fungus at the center and polynuclear cells.

PLATE 3

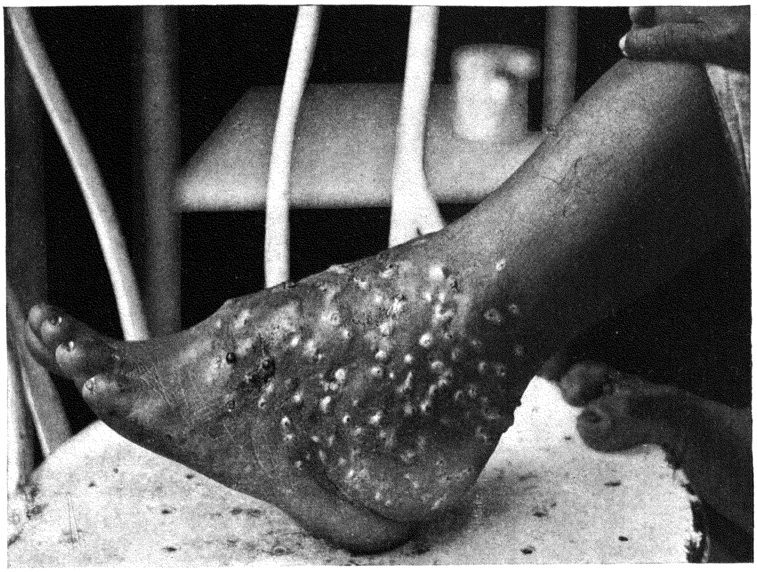
Culture in glycerin broth 3 weeks old; a confluent wrinkled yellowish surface growth.

PLATE 4

FIG. 1. Young culture on hormone blood agar, recovered from guinea-pig nodule. Animal inoculated with subplant of original strain, shows rosette ocher yellow colonies, umbilicated. (Cultures 5 days old.)

2. Original pure culture obtained from patient's foot, growing on hormone blood agar; ocher yellow colonies become confluent and acquire a pinkish coloration with age. (Cultures 24 days old.)

3. Old culture (23 days old) on Saboraud's medium, shows powdery whitish growth colonies which never become yellow or pink.



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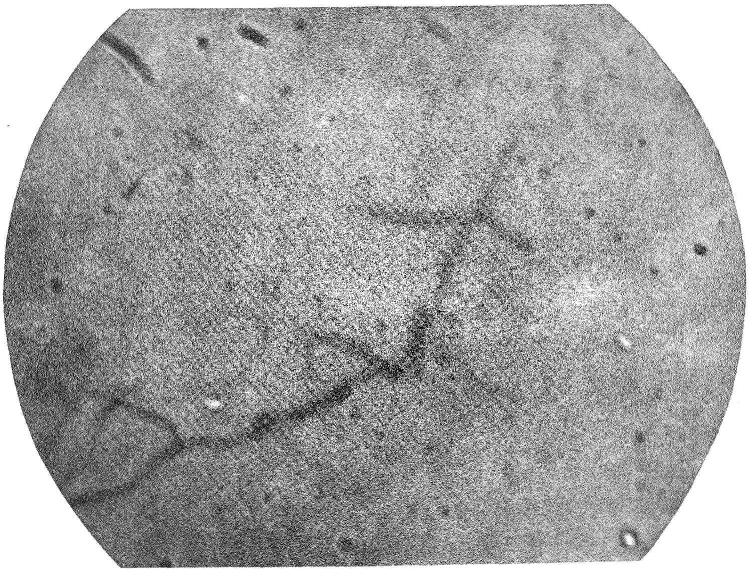

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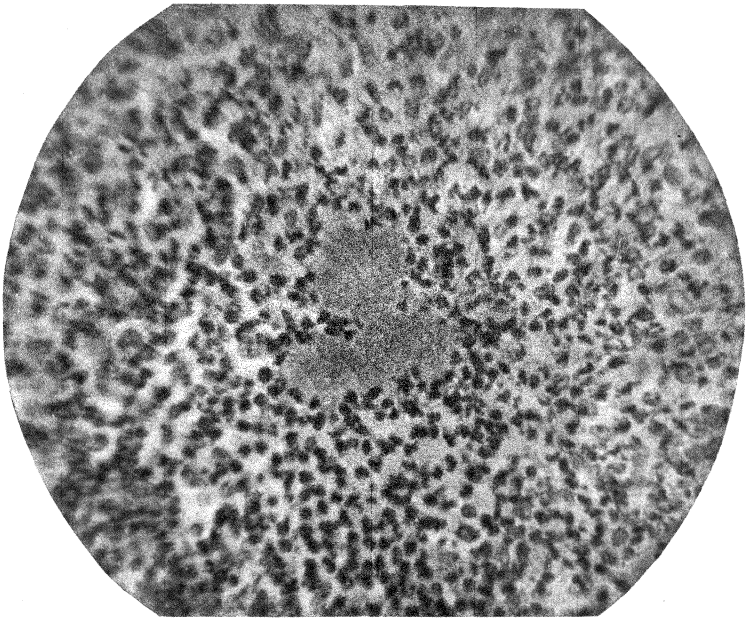

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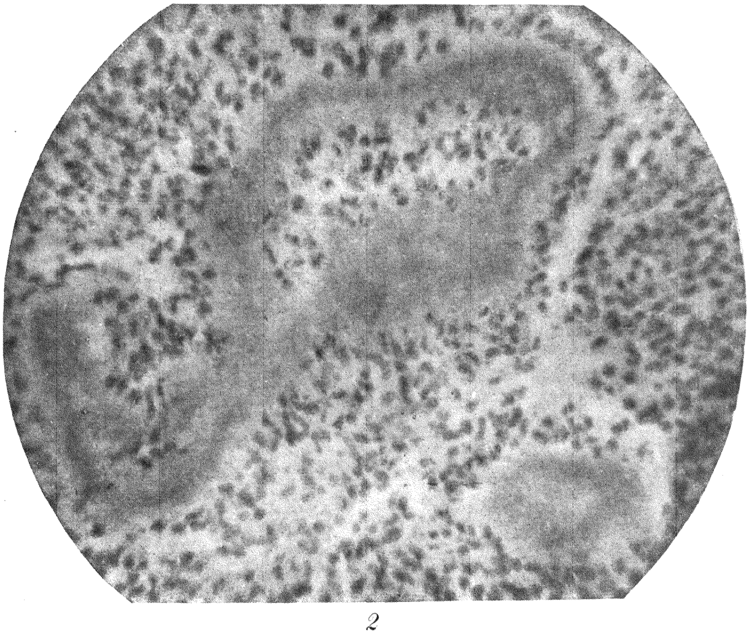

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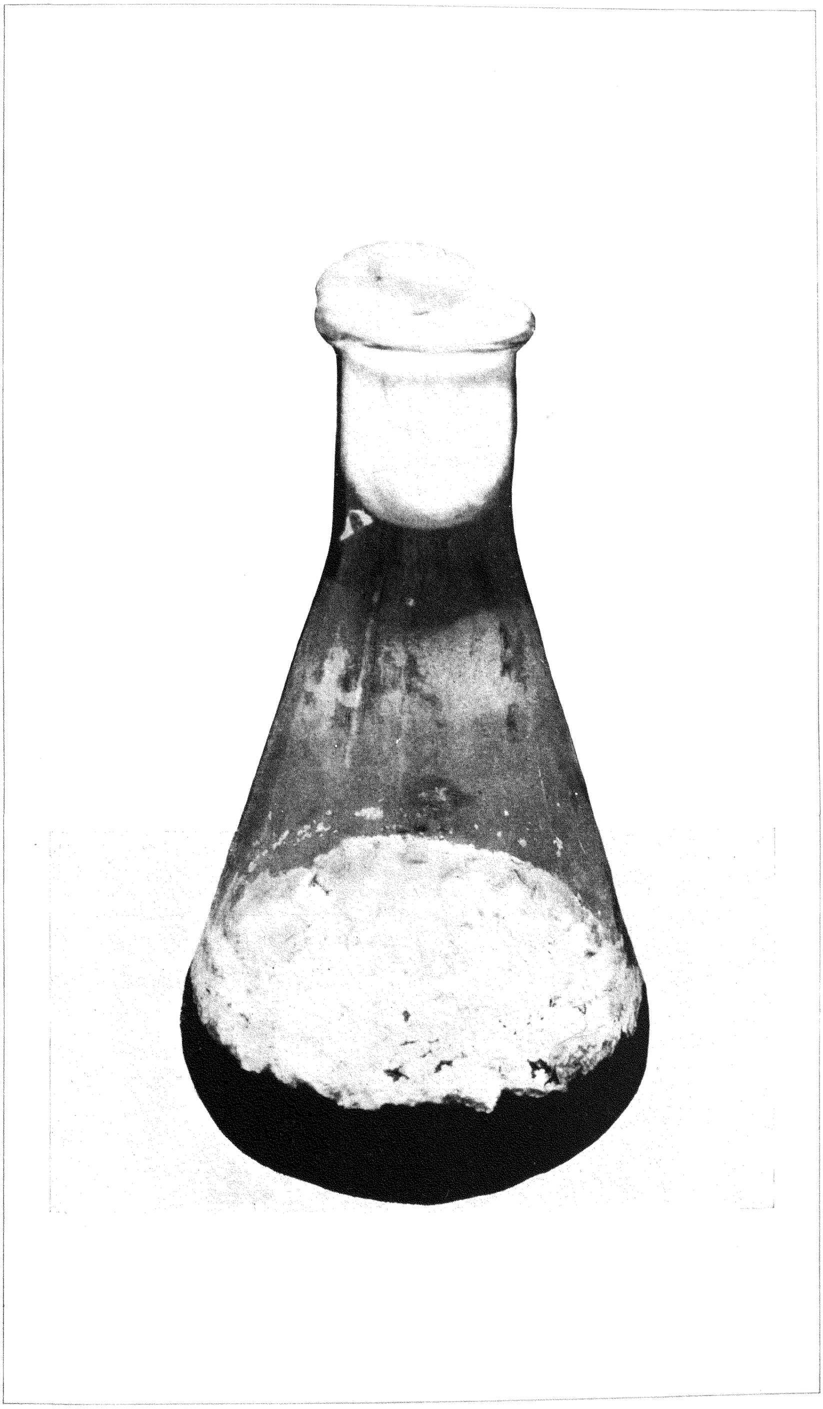

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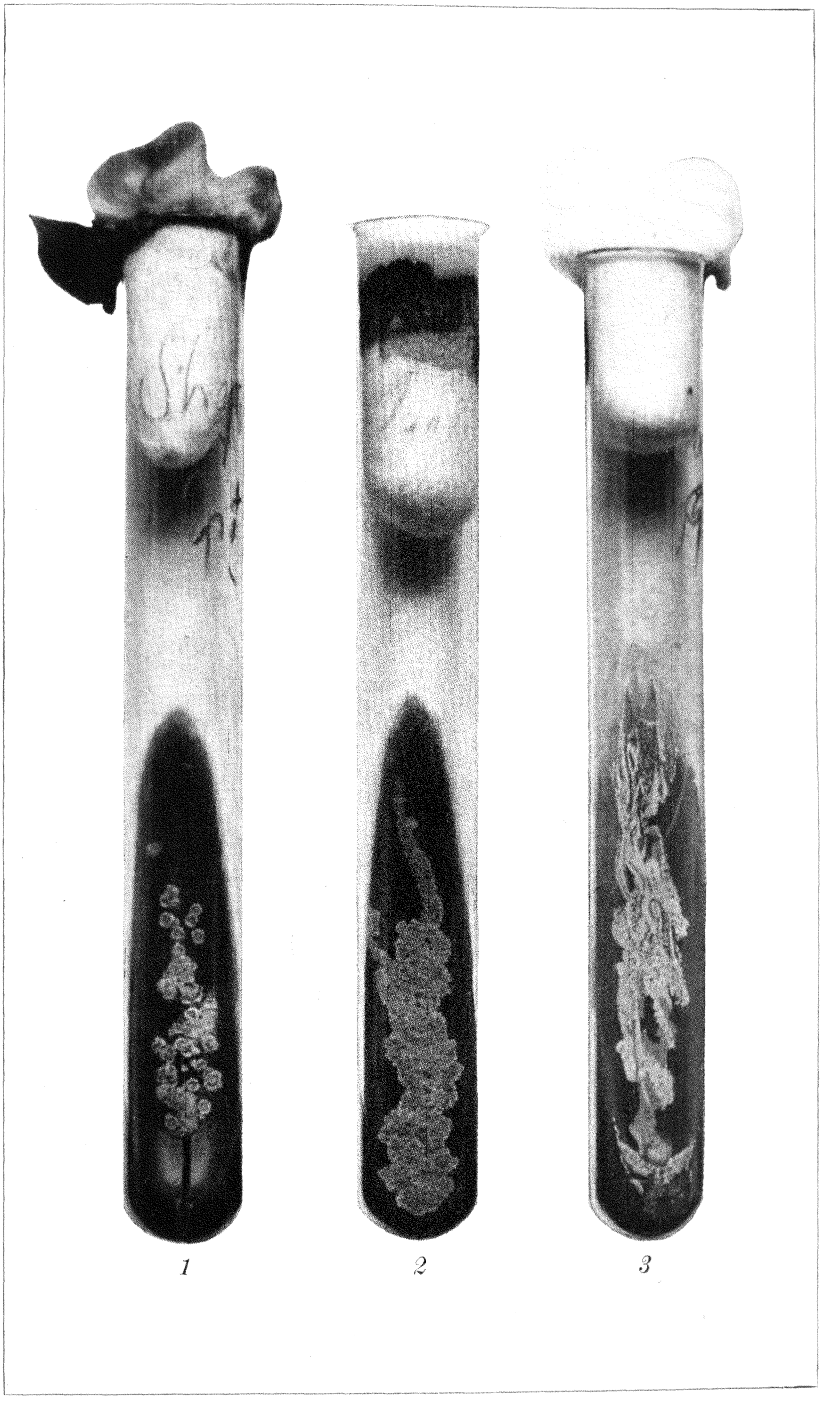

PLATE 4.

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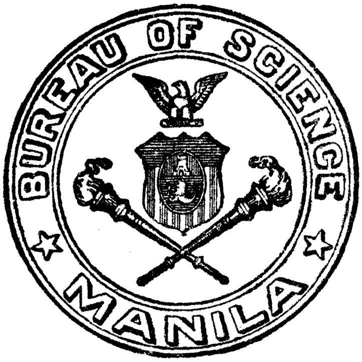
VOL. 49, NO. 4 DECEMBER, 1932

THE PHILIPPINE JOURNAL OF SCIENCE



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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 49 DECEMBER, 1932 NO. 4

NEW OR NOTEWORTHY PHILIPPINE ORCHIDS, III

By OAKES AMES

Professor of Botany in Harvard University

and

EDUARDO QUISUMBING

Botanist, Bureau of Science, Manila

TWENTY-EIGHT PLATES

The third paper of this series is essentially like its predecessors, the last number of which was published in February, 1932.[1] The present paper contains the descriptions of six hitherto undescribed species and one variety, with notes and redescriptions of *Dendrochilum Weberi, Gastrochilus calceolaris*, and *Microsaccus Wenzelii*, as well as a record and description of one species (*Cymbidium pubescens*) previously described from extra-Philippine material now found for the first time in the Archipelago. All the illustrations and the descriptions in the text have been prepared from living plants. The colored illustrations and ink sketches were made by Messrs. J. M. Salazar and P. Ramos, draftsmen of the division of botany, Bureau of Science. Plates 11 and 12 were executed by F. Guerrero, a draftsman of the same division. All the types of the new species and varieties have been deposited in the herbarium of the Bureau of Science, with the isotypes in the herbarium of the senior author. Available isotypes will be distributed to the herbarium of the New York Botanical Garden and other herbaria.

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[1] Philip. Journ. Sci. 47 (1932) 197.

Genus COELOGYNE Lindley

COELOGYNE REMEDIOSAE sp. nov. § Flexuosæ. Plates 1, 3, and 14.

Radices glabrae, plus minusve 2 mm in diametro, carnosae et pallidae ut videtur. Rhizoma 8 ad 10 mm in diametro. Pseudobulbi in serie, anguste cylindracei, 11 ad 13 cm longi, 2 ad 2.7 cm in crassitudine infra medium, utrinque attenuati, diphylli, in rhizomate crasso repenti 2 ad 3 cm inter se distantes; juniores vaginis membranaceis, obtusis vel acutis, usque ad 7 cm longis vestiti. Folia cum petiolo 22.5 ad 26 cm longa, 5.5 ad 8.5 cm lata, elliptico-oblonga vel elliptica, breviter acuminata, subtus prominenter quinquenervia. Scapus initio foliis juvenilibus synanthus, 23 ad 31.5 cm longus, basi nuda, pauciflorus; rhachis gracilis, erecta vel arcuata. Bracteae inflorescentiae ignotae. Flores succedanei. Pedicellus cum ovario circiter 1.5 cm longus. Sepala lateralia oblonga, abrupte acuta vel subacuta, 2.5 ad 2.9 cm longa, 1.0 ad 1.3 cm lata, subcarnosa. Sepalum dorsale oblongo-lanceolatum, acutum, 2 ad 2.2 cm longum, 0.8 ad 1.0 cm latum. Petala linearia, obtusa, apice obliquo apiculata, 2.5 ad 2.6 cm longa, 2.5 ad 3 mm lata, erecta. Labellum subcarnosum, trilobatum, circiter 2.5 cm longum; lobis laterales breves, subquadrati, apice valde obtusati vel rotundati, parte libera circiter 3 mm longa; lobus intermedius in circuitu suborbicularis, circiter 1.5 cm longus, 1.5 cm latus, apice subrotundatus, minute apiculatus, margine undulato; discus carinis 2, antice altis ornatus, ad basim 5-carinatus. Columna valde arcuata, carnosa, circiter 1.8 cm longa, apicem versus alata.

Roots glabrous, fibrous, about 2 mm in diameter, straw-colored. Rhizomes creeping, 8 to 10 mm in diameter. Pseudobulbs in linear series, narrowly cylindric, 11 to 13 cm high, 2 to 2.7 cm in diameter, tapering at both ends, diphyllous, 2 to 3 cm distant. Sheaths membranaceous, obtuse or acute, up to 7 cm long. Leaves with petiole 22.5 to 26 cm long, 5.5 to 8.5 cm wide, elliptic-oblong or elliptic, acute, conspicuously 5-nerved beneath. Scapes terminal, arising between the leaves of the immature pseudobulbs, the base naked, few-flowered, 23 to 31.5 cm long; rachis slender, erect or curved at the top. Bracts of the inflorescence early deciduous, not seen. Flowers odorless, produced in succession. Pedicellate ovary about 1.5 cm long, the ovary ridged. Lateral sepals oblong, abruptly acute or subacute, 2.5 to 2.9 cm long, 1.0 to 1.3 cm wide, somewhat fleshy. Dorsal sepal oblong-lanceolate, acute, 2 to 2.2 cm long, 0.8 to 1.0 cm wide. Petals linear, obtuse, minutely apiculate at the oblique apex, erect, 2.5 to 2.6 cm long, 2.5 to 3 mm wide. Labellum somewhat fleshy, trilobed, about 2.5 cm long; lateral lobes rather short, subquadrate, the apex broadly obtuse or rounded, free portion about 3 mm long; middle lobe suborbicular, about 1.5 cm long, 1.5 cm wide, apex subrounded with a minute apicule, the margin undulate; disc with 5 low keels at the base, two of the keels increasingly high, conspicuous and wavy toward the apex, extended to one-third or one-half of the middle lobe; the 3 short basal keels 3 to 3.5 mm long. Column about 1.8 cm long, arcuate, fleshy, conspicuously winged at the apex.

LUZON, Manila, cultivated in the gardens of Mrs. Remedios C. Gonzales, *Bur. Sci. 82232 Quisumbing,* February 24, 1931. The plants flowered again a month earlier in Mrs. Gonzales's gardens this year (1932). The living plants, purchased from a peddler, were of uncertain origin but they were surely Philippine. The sepals are sea-foam yellow and deep sea-foam green at the middle; the petals are sea-foam green; column glass green, the apical margin pale grass green; the labellum marguerite yellow except the lamellæ, lateral lobes and the markings at the center of the middle lobe snuff brown.[1]

Among the known Philippine coelogynes, this species appears most closely related to *C. marmorata* Reichb. f., but differs in its longer scape and in the keels of the lip. In habit it suggests *C. bilamellata* Lindl., *C. candoonensis* Ames and *C. longirachis* Ames, but it has much larger flowers and a dissimilar lip.

Genus DENDROCHILUM Blume

DENDROCHILUM WEBERI Ames § Eudendrochilum. Plates 1, 4, and 15.

Dendrochilum Weberi AMES in Philip. Journ. Sci. 8 (1913) Bot. 410, Orch. 5 (1915) 65.

Rhizoma elongatum, repens, gracile, 2 ad 2.5 mm in diametro, ad nodos radicans. Pseudobulbi anguste cylindracei, 2 ad 3 cm longi, 2 ad 5.5 cm distantes. Folia breviter petiolata, coriacea, oblongo-lanceolata vel peranguste elliptica, in sicco nervosa, 7 ad 8.5 cm longa, 1 ad 2 cm lata, utrinque attenuata, ad apicem acuta. Scapus lateralis in basi pseudobulbi, plus minusve foliis longior, 8 ad 11 cm longus, gracilis, flexuosus vel pendulus, ad basim vaginis tubularibus bracteiformibus inclusus; bracteis inflorescentiae glabris, lanceolatis, usque ad 2 mm longis. Flores in racemis laxis dispositi. Sepala lateralia lineari-lanceolata, subacuta, circiter 5 mm longa, 1.25 mm lata, 3-nervia, levissime falcata. Sepalum dorsale lineari-lanceolatum, acutum, circiter 5 mm longum, 1.5 mm latum, 3-nervium. Petala lineari-oblanceolata, obtusa vel acuta, circiter 4 mm longa, 1 mm lata, 1-nervia. Labellum obovato-oblongum, medio utrinque leviter angustatum, ad apicem late rotundatum vel retusum, circiter 2 mm longum, 1 mm latum, 3-nervium, ad basim bicallosum; pars inferior abrupte reflexa. Columna brevis, ad apicem trilobatam dente medio bidentato, dentibus lateralibus erectis, triangulari-linearibus. Pollinia quatuor.

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[1] The color terms used are mostly from Ridgway's Color Standards and Color Nomenclature (1912).

Rhizomes creeping, elongated, slender, 2 to 2.5 mm in diameter, copiously rooting at the nodes. Roots fibrous, branching. Pseudobulbs narrowly cylindric, 2 to 3 cm long, rugose when dry, 2 to 5.5 cm apart. Leaves shortly petioled, coriaceous, oblong-lanceolate or very narrowly elliptic, 7 to 8.5 cm long, 1 to 2 cm wide, tapering at both ends, the apex acute; petioles 2 to 4 mm long. Scapes commonly longer than the leaves, 8 to 11 cm long, slender, flexuose or pendant, arising from the base of the pseudobulbs, sheathed at base with several tubular bracts. Bracts subtending the flowers lanceolate, acute, concave, up to 2 mm long. Flowers marguerite yellow, laxly disposed on the racemes. Lateral sepals linear-lanceolate, subacute, about 5 mm long, 1.25 mm wide, 3-nerved, slightly falcate. Dorsal sepal linear-lanceolate, acute, about 5 mm long, 1.5 mm wide, 3-nerved. Petals linear-oblanceolate, obtuse or acute, about 4 mm long, 1 mm wide, 1-nerved. Labellum glabrous, obovate-oblong, in the middle on each side slightly narrowed, reflexed at the base, about 2 mm long, 1 mm wide, broadly rounded or retuse at the apex, the base subhastate and bicallose, 3-nerved. Column very short, arcuate, at the apex trilobed, the middle tooth bidentate, the lateral arms triangular-linear and suberect. Pollinia 4.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84546 Quisumbing*, May 19, 1931. The living plants were collected by Messrs. M. Ramos and P. Convocar from near the banks of Camahalan River, Agusan Province, Mindanao, growing on rocks, April 30, 1931. Living specimens are now growing on the tuff (Guadalupe stone) walls in the Bureau of Science orchid house in Manila.

This is the third collection of this species. In general habit it very closely resembles *D. aurantiacum* Blume, but differs in the details of the flowers.

Genus AGROSTOPHYLLUM Blume

AGROSTOPHYLLUM SACCATILABIUM sp. nov. Plates 1, 5, 16, and 17.

Aff. *A. inocephalum* (Schauer) Ames. Planta glabra, ad basim foliis discessis, nuda, supra foliosa, 32 ad 45 cm alta. Caules complanati, vaginis foliorum tecti. Folia disticha, anguste lineari-oblonga; lamina 12 ad 17 cm longa, 2 ad 3 cm lata, in sicco subcoriacea, obtusa; vaginae foliorum imbricatae, persistentes, flavidae et atromarginatae, longivaginantae, usque ad 5 cm longae. Inflorescentiae terminalis, densissime capitata, usque ad 3.5 cm in diametro. Flores albidi, parvi, in racemis paucifloris numerosissimis capitulum formantes, bracteis imbricatis subtendentibus, 4 ad 6 mm in diametro. Sepala lateralia carinata, cucullata, ovato-oblonga, subacuta, circiter 4 mm longa, 2 mm lata, 3-nervia. Sepalum dorsale ovatum, subacutum, 3-nervium, circiter 3.5 mm longum, 2.25 mm latum. Petala lineari-lanceolata, apice ipso paulo ampliata, circiter 3.5 mm longa, 0.75 mm lata. Labellum saccatum, in circuitu suborbiculare; parte inferiore (hypochilio) semiorbiculari, saccata, circiter 1.5 mm longa; parte terminali (epichilio) valde saccata, semiorbiculari, ad apicem rotundata, circiter 2.5 mm longa; callus transversus. Columna crassa, circiter 2 mm longa. Pollinia 8.

A glabrous epiphyte, rather stout, 32 to 45 cm high; stems tufted, flattened, narrowed at the base. Leaves restricted to the upper portion of the stems, distichous, jointed with persistent clasping rigid bases; lamina 12 to 17 cm long, 2 to 3 cm wide, narrowly linear-oblong, obtuse, when dry subcoriaceous; sheaths up to 5 cm long. Inflorescences terminal, capitate, pluribracteate, up to 3.5 cm in diameter. Flowers very numerous, in few-flowered racemes, very crowded, marguerite yellow, 4 to 6 mm across. Lateral sepals carinate, cucullate, ovate-oblong, subacute, about 4 mm long, 2 mm wide, 3-nerved, the two side nerves not reaching the apex. Dorsal sepal ovate, subacute, about 3.5 mm long, 2.25 mm wide, 3-nerved. Petals linear-lanceolate, about 3.5 mm long, 0.75 mm wide. Labellum saccate, suborbicular in outline, about 3 mm long; hypochile semiorbicular, saccate, about 1.5 mm long, separated from the epichile by a transverse callus; epichile saccate, semiorbicular, the apex broadly rounded, about 2.5 mm long. Column stout, about 2 mm long. Pollinia 8.

LUZON, Benguet Subprovince, Baguio, Gardens of the Mansion House, *Bur. Sci. 82229 Quisumbing,* May 6, 1931. The living plants were first seen in the gardens of the Mansion House at

Baguio; the origin of the specimens is not known, but we are assured that the orchid peddlers in Baguio collected them from the mountains in the vicinity of Baguio.

A species closely allied to *Agrostophyllum inocephalum* (Schauer) Ames, but differing radically in the shape of the epichile.

Genus DENDROBIUM Swartz

DENDROBIUM AURICULATUM sp. nov. Plates 1, 6, and 18.

Aff. *D. papilio.* Caulibus simplicibus, basibus foliorum auriculatis, floribus albidis et basi auriculata labelli plus ovati differt.

Stems numerous, crowded in a clump, 30 to 82 cm high, erect or suberect, not branched, terete, greenish yellow, 1.5 to 3 mm in diameter; internodes up to 2.5 cm long. Leaves linear-lanceolate, the apex narrowed, acute, unequally bilobed with the subulate lobules 1 to 2 mm long, the base prominently auricled with the lobules extending across the stems, the lamina 8 to 12.5 cm long, 4 to 8 mm wide, somewhat rigid; the sheaths tubular, purplish. Flowers odorless, showy, appearing singly on the naked termination of the stems, 6 to 6.5 cm across. Flowering stems usually defoliated (if leaves are present when the plant is in flower, only the apical ones remain). Pedicellate ovary slender, 1.8 to 2 cm long. Sepals and petals pure white, lined at the base with purple. Lateral sepals oblong-lanceolate, obtuse, including the spur 4 to 4.1 cm long, obtuse, greenish and lined with purple. Dorsal sepal oblong, obtuse, 2.5 to 2.6 cm long, 1 to 1.1 cm wide at the widest portion, 7-nerved. Petals obliquely oblong-elliptic, obtuse, 2.5 to 2.7 cm long, 1.1 to 1.2 cm wide, 5-nerved. Labellum conspicuously unguiculate, simple; claw linear, the lower third tubular saccate, 1.9 to 2 cm long, conspicuously green, lamina (when expanded) broadly ovate-cordate, obtuse, margins minutely dentate or crenate-dentate, membranaceous, 2 to 2.1 cm long, 1.5 to 1.6 cm wide, with three obscure central lines throughout, pure white. Gynostemium very short and stout, clinandrium tridentate with the central tooth linear-subulate, extended into a long foot, including the foot 1.9 to 2 cm long. Anther oblong-ovoid, obtuse, about 3 mm long, 2 mm wide.

In the herbarium of Oakes Ames is a plant from Mindanao representing this species. It differs from the typical specific form in its conspicuously smaller flowers of which the petal is 1.5 cm long and about 6.5 mm wide and the entire lip, including the claw, about 2.5 cm long. Its data are Mindanao, District

of Davao, Divide on Apo Ridge, altitude 3,050 feet. Epiphyte. Flowers white. *C. M. Weber 246,* August 25, 1911.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84542 Quisumbing,* March 11, 1931. The living plants were collected from the mountains near the source of Angat Irrigation System, Bulacan Province, growing on rocks. The plants flowered for the second time earlier (January, 1932).

A very interesting orchid and worthy of a place in orchid gardens. The species doubtless is closely allied to *Dendrobium papilio* Loher, but differs in its unbranched stems, leaves with conspicuously auricled bases, and the pure white flowers, purple-lined at the bases of petals and sepals, with green throat and claw. The margins of the labellum are minutely dentate. The plants thrive well in earthen pots with tuff and humus.

DENDROBIUM GUERREROI sp. nov. Plates 1, 7, 19, and 20.

Aff. *D. O'Brieno* et *D. amethystoglosso.* Caules aggregati, elongati, suberecti, basi attenuati, 30 ad 76 cm longi, usque ad 8 mm in diametro. Folia lanceolata vel oblongo-lanceolata, 7.5 ad 10.5 cm longa, 1.6 ad 2.5 cm lata, apice attenuata, acuta, membranacea. Racemi penduli, pauci et laxiflori, usque ad 8 cm longi, 10- ad 13-flori, e caulibus defoliatis orientes. Flores 3 ad 3.3 cm longi, 2 ad 2.2 cm lati. Sepala lateralia oblique oblong-lanceolata, acuta, 13.5 ad 14 mm longa, 7.5 ad 8.5 mm lata, 7-nervia, mentum formantia; mentum elongatum, saccatum, superne rectum vel leviter curvatum, obtusum, circiter 1.5 cm longum. Sepalum dorsale oblongo-lanceolatum, subacutum, 13 ad 15.5 mm longum, 5 ad 6 mm latum, 7-nervium. Petala oblongo-elliptica, obtusa, 14 ad 15 mm longa, 6 ad 7 mm lata, 5-nervia. Labellum simplex, elongatum, 25 ad 27 mm longum, basi unguiculata lineari, in positu naturali complanatum, cum pede gynostemii connatum; lamina ovata, 15 ad 17 mm longa, expansa 12 ad 13 mm lata, margine levissime crenulata vel integerrima, antice late rotundata vel leviter retusa, plus minusve apiculata; discus fascia una elevatula carnosa praeditus. Gynostemium brevissimum, crassum, tridentatum; stelidia lateralia recurvata, lata, obtusa, dens medius tenuis, linearis. Anthera ovoidea, circiter 2 mm longa.

Stems terete, aggregated, elongate, suberect, 30 to 76 cm long, up to 8 mm in diameter at the widest portion, narrowed at the base. Leaves distichous, deciduous, lanceolate or oblong-lanceolate, 7.5 to 10.5 cm long, 1.6 to 2.5 cm wide, nervose, membranaceous, greenish, when young flushed with purple, narrowed

to the acute apex, articulated to tubular sheaths. Leaf-sheaths purplish when young, otherwise green, membranaceous, deciduous on the lower part of the plant. Racemes pendulous, few- and laxly flowered, up to 8 cm long. Flowers 10 to 13, 2 to 2.2 cm across, 3 to 3.3 cm long, with rather straight or slightly inflexed spur. Bracts pellucid, minute, triangular, acute, up to 3.5 mm long, white flushed with purple. Pedicellate ovary 1.5 to 2.5 cm long, rose purple, pedicel slender. Lateral sepals obliquely oblong-lanceolate, acute, somewhat cucullate at the tip, 13.5 to 14 mm long near the posterior margin, 7.5 to 8.5 mm wide, 7-nerved, forming with the column-foot a mentum or spur which is elongate, straight or slightly curved, obtuse, about 1.5 cm long. Dorsal sepal slightly cucullate with the tip bent forward, oblong-lanceolate, subacute, 13 to 15.5 mm long, 5 to 6 mm wide, 7-nerved. Petals spreading, oblong-elliptic, obtuse, 14 to 15 mm long, 6 to 7 mm wide, 5-nerved, margin entire. Labellum simple, elongate, 25 to 27 mm long, claw linear, flattened, attached to the foot of the column, lamina ovate, 15 to 17 mm long, 12 to 13 mm wide at the widest portion (when expanded), the apex broadly rounded or slightly retuse, with a very minute mucro in the notch, the margin entire or finely crenulate; disc provided with a single broad central fleshy keel which is glabrous and extends from the column-foot nearly to the apex of the lip. Column white, very short and stout, 2 to 2.5 mm long, extended into an elongated foot. Anther ovoid, about 2 mm long.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84541 Quisumbing*, July 27, 1932. The living plants were originally gathered by the botanical collectors Maximo Ramos and Pascual Convocar, of the Bureau of Science, in May, 1931, from Dinagat Island, near Mindanao. The plants are now being cultivated in the Bureau of Science orchid house, and this description was based on specimens which flowered in Manila on July 25, 1931. The flowers are showy and odorless, and last for two or three days. Pedicellate ovary rose purple; sepals naphthalene yellow, usually flushed with rose purple on the back (older flowers become cream-colored); petals paler, marguerite yellow; spur primrose yellow with shades of honey yellow at the tip and flushed on the back with rose purple; column-foot primrose yellow and minutely dotted with rose purple; gynostemium and anther white; labellum chamois and minutely dotted within (particularly at the throat) with rose purple except the tip which is marguerite yellow, and the raised disc rosolane pink which extends from the column-foot to the very lip.

A species doubtless belonging in the group with *Dendrobium O'Brienum* Kränzl. and *Dendrobium amethystoglossum* Reichb. f. It is especially close to the first but differs in its much shorter and few-flowered racemes, in the spur, and especially the labellum.

This species is dedicated to Dr. Leon Ma. Guerrero, chief of the division of botany of the Bureau of Science and specialist in Philippine medicinal plants. The junior author greatly appreciates the encouragement Doctor Guerrero has given him during the prosecution of these studies.

Genus CYMBIDIUM Swartz

CYMBIDIUM PUBESCENS Lindl. Plates 2, 8, 21, and 22.

Cymbidium pubescens LINDL. Bot. Reg. **26** (1840) Misc. p. 75, *27* (1841) *t. 38;* J. J. SM. Fl. Buitenzorg. **6** (Orch. Java) (1905) 483, Fig.-Atlas (1911) *fig. 368;* SCHLECHTER, Die Orchideen (1927) 362.

Cymbidium aloifolium BLUME Bijdr. (1825) 378.

Cymbidium bicolor LINDL. (p. p.) Gen. & Sp. Orch. (1833) 164; MIQ. Fl. Ind. Bat. **3** (1859) 707; REICHB. F. Walp. Ann. **6** (1863) 625.

"*C. pubescens;* foliis ensiformibus striatis apice oblique bidentatis, racemo brevi pendulo, bracteis minimis squamaeformibus, sepalis petalisque linearibus acutiusculis, labelli trilobi basi saccati intus pubescentis laciniis lateralibus acutis intermedia oblonga subundulata obtusa, lamellis rectiusculis medio interruptis." Bot. Reg. 26 (1840), misc. p. 75, no. 177. Lindl. 27 (1841) *t. 38.*

An epiphyte, much the habit of *Cymbidium atropurpureum* (Lindl.) Rolfe. Leaves clustered, coriaceous, sessile, dark green, ligulate-linear, 50 to 53 cm long, 1.75 to 1.9 cm wide, striated, apex very obliquely notched. Racemes pendulous, 5- to 10-flowered, 15 to 25 cm long, arising from the sides of the base; the peduncles glabrous, about 11.5 cm long, 4 mm in diameter, clothed at the base with 3 tubular sheaths; the sheaths light green, the basal ones shortest, oblong (when expanded), acute, about 3 cm long, 2 cm wide, the two upper ones linear-lanceolate, acute, 4 to 4.5 cm long, about 1.5 cm wide. Floral bracts minute, squamiform, triangular, acute, 2.5 to 3 mm long. Pedicellate ovary 1.3 to 1.5 cm long. Flowers odorless, about 3 cm across. Lateral sepals spreading, narrowly oblong or slightly oblanceolate, acute, slightly oblique, 1.5 to 1.7 cm long, 5 to 5.5 mm wide, 7-nerved. Dorsal sepal similar, erect. Petals spreading, lanceolate or elliptic-lanceolate, acute, 1.4 to 1.55 cm long, 4.75 to 5 mm wide, 5-nerved. Labellum trilobed, suborbicular-ovate in outline when expanded, saccate at the base, minutely ciliate on both surfaces, more so within and on the margins; lateral lobes semiovate with free apices, short, triangular, porrect, acute, 3 to 3.5 mm long; middle lobe broadly oblong to suborbicular, 7 to 7.5 mm long, 5.5 to 6.25 mm wide, the apex rounded, recurved, apiculate at the very tip; the disc with a pair of subparallel fleshy lamellæ or ridges at the base in front of which stands another pair of smaller calli. Column long, arcuate, without a foot, slightly thickened at the apex, 10 to 11.5 mm long. Anther semiglobose. Pollinia 2, complanate-pyriform.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84547 Quisumbing,* January 13, 1931. The living plants, which are now in cultivation in the Bureau of Science orchid house, were collected near Butuan, Agusan Province, Mindanao, growing on trees at low altitudes. The sepals and petals etruscan red or acajou red broadly edged with deep colonial buff; lateral lobes of the labellum ivory yellow dotted with ox-blood red; middle lobe of the labellum naples yellow and tipped with ox-blood red. Column pompeian red; anther light orange yellow above and amber brown below.

Lindley, Bot. Reg. 27 (1841) *t. 38,* states—"Although the woods of Sincapore have been so often examined by Botanists it seems as if the forms of vegetation there were inexhaustible. The species now figured was met with by Mr. Cuming who sent it to Messrs. Loddiges." This species, which is distributed over Malay Peninsula, Sumatra, and Java, and Banca and Siam, fide Ridley, doubtless belongs in the group with *C. finlaysonianum* Lindl. and *C. atropurpureum* (Lindl.) Rolfe. It has the general habit of *C. atropurpureum* and resembles it in the form and size of leaves, but is distinct from both species in having very much shorter racemes, smaller flowers, and pubescent labellum as well as in the color of the flowers. *Cymbidium pubescens* Lindl. is here for the first time reported from the Philippines, although several sterile and fruiting specimens in the herbarium of Oakes Ames perhaps represent it. The plant thrives best in orchid pots with crushed tuff as a substratum or in wooden baskets. The cymbidiums of the Philippines are some of the most hardy of orchids and they even grow luxuriantly perched on branches of trees.

Genus SARCOCHILUS R. Brown

SARCOCHILUS BENGUETENSIS sp. nov. Plates 1, 9, and 23.

Herba epiphytica, carnosa. Caules leviter elongati, 8 ad 13 cm longi, teretes, radices crassas proferentes. Folia disticha, valde carnosa, rigida, oblonga vel elliptico-oblonga, obtusa, 6 ad 8 cm longa, 1.8 ad 2.3 cm lata, ad apicem inaequaliter biloba, in sicco rugosa, coriacea, 6 ad 12 mm distantia, vaginis persistentibus. Inflorescentiae breves, foliis multo breviores, usque ad 3 cm longae, pedunculus glaber, usque ad 1.2 cm longus; rhachis inflorescentiae leviter incrassata, 2 ad 3 mm in diametro; bracteae squamiformes, circiter 4 mm longae, obtusae. Flores odoratissimi, in racemo cylindraceo laxo pauciflora dispositi, 10.5 ad 11 mm lati; pedicellus cum ovario gracilis, 6 ad 7 mm longus; bracteae florales minutae, triangulares, acutae, usque ad 2 mm longae. Sepala lateralia oblique late ovata, obtusa ad apicem dorso leviter carinata, circiter 4 mm longa, 3.5 ad 3.75 mm lata, 3-nervia. Sepalum dorsale cucullatum, oblongo-ovatum, obtusum, leviter retusum, circiter 4 mm longum, 2.75 latum, 3-nervium. Petala oblongo-lanceolata vel elliptico-lanceolata, valde obtusa, uninervia, circiter 3.75 mm longa, 1.25 mm lata. Labellum pedi columnae affixum, calcaratum, 3-lobatum; lobi laterales erecti, petaloidei, lineares, obtusi, circiter 2.75 mm longi, 0.75 mm lati; lobus intermedius carnosissimus, abbreviatus, papillosus. Calcar supra lobum medium cylindraceo-conicum, complanatum, late obtusum, circiter 4 mm longum, 2 mm latum. Gynostemium brevissimum, circiter 1.5 mm longum, in pedem circiter 2.5 mm longum extensum.

An epiphytic herb; the stems somewhat elongated, 8 to 13 cm long, terete. Leaves distichous, very fleshy, rigid, oblong or elliptic-oblong, obtuse, 6 to 8 cm long, 1.8 to 2.3 cm wide, unequally and minutely bilobed at the apex, when dry rugose and coriaceous, 6 to 12 mm distant, articulated to persistent sheaths. Inflorescences much shorter than the leaves, few-flowered, up to 3 cm long; the peduncles glabrous, up to 1.2 cm long; the rachis 2 to 3 mm in diameter, provided with squamiform obtuse bracts about 4 mm long. Flowers very fragrant, 10.5 to 11 mm across; pedicellate ovary slender, 6 to 7 mm long; floral bracts minute, triangular, acute, up to 2 mm long. Lateral sepals broadly ovate, very oblique, obtuse, keeled on the back at the apex, about 4 mm long, 3.5 to 3.75 mm wide, 3-nerved. Dorsal sepal cucullate, oblong-ovate, obtuse, somewhat retuse, about 4 mm long, 2.75 mm wide, 3-nerved. Petals oblong-lanceolate or elliptic-

lanceolate, broadly obtuse, 1-nerved, about 3.75 mm long, 1.25 mm wide. Labellum attached to the foot of the column, spurred, 3-lobed; lateral lobes erect, petaloid, linear, slightly curved, obtuse, about 2.75 mm long, 0.75 mm wide; middle lobe a short fleshy, conical, papillose tooth; spur cylindric-conic, dorsoventrally flattened, about 4 mm long, 2 mm wide, the tip broadly rounded or subtruncate. A pair of minute uncinate lobules stand inside the base of the lateral lobes. Gynostemium very short, about 1.5 mm long, extended into a foot about 2.5 mm long. Pollinia 4, complanate-ovoid, unequal.

LUZON, Benguet Subprovince, Baguio, gardens of the Mansion House, *Bur. Sci. 82203 Quisumbing,* May 6, 1931. The living plants were originally from the mountains near Baguio, but the exact locality is unknown. At present the living plants are growing in the Bureau of Science orchid house. Sepals and petals white dotted with purple-red; labellum white except the inner surfaces of the lateral lobes which are dotted with purple-red; anther yellow; back side of the column carmine; pedicellate ovary marguerite yellow.

Among the Philippine species, this plant appears to be allied to *Sarcochilus palawanensis* Ames but differs strikingly in its short racemes and in the dissimilar form of the perianth segments.

Genus PHALAENOPSIS Blume

PHALAENOPSIS LUEDDEMANNIANA Reichb. f. var. PURPUREA var. nov. Plates 2, 10, and 24.

Haec varietas floribus omnino purpureis haud striatis a *P. Lueddemanniana* differt.

Plant suberect. Leaves oblong-elliptic to narrowly obovate, thick, fleshy, slightly rigid, subacute, 8.5 to 14 cm long, 4.5 to 6 cm wide, shining on both surfaces. Scapes not branching, few-flowered; rachis 10.5 to 13.5 cm long. Flowers odorless, about 3.5 cm across, true purple and absolutely without transverse bars on the sepals and petals in front, and obscurely reticulated with white on the back. The tips of sepals are white. Pedicellate ovary white, 3 to 3.5 cm long. Lateral sepals obliquely ovate, acute, apiculate, 1.9 to 2.2 cm long, 1 to 1.3 cm wide (when spread out), 9-nerved. Dorsal sepal erect, elliptic-lanceolate, acute and apiculate, 1.9 to 2.2 cm long, about 0.9 cm wide, 9-nerved. Petals oblong-elliptic, subobtuse, 1.8 to 2 cm long, 0.8 to 0.9 cm wide, 7-nerved. Labellum fleshy, 3-lobed; lateral lobes erect, quadrate-oblong, bidentate at the broad apex, with a prominent fleshy callus above the middle, about 7 mm long, light orange except the terminal horns which are mallow pink and the base which is white; middle lobe lanceolate or oblong-lanceolate, obtuse, 1.4 to 1.5 cm long, 0.6 to 0.7 cm wide at the widest portion. Disc provided with several distinct calli: near the base, between the side lobes, an obscurely 3-lobed plurituberculate callus; at the base of the middle lobe a pair of slender sharp teeth and a longer thin high median keel which extends to the middle of the terminal lobe where it is continued by irregular teeth and terminates in a fleshy callus (toothed or fringed at the base) which extends to the apex of the lip. Column 1 to 1.3 cm long, white with a mallow pink base.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 84550 Quisumbing*, June 6, 1931. The living plants were presented to the junior author by Mr. Constinoble, of Del Carmen, Pampanga Province, Luzon, who collected them at Balete Pass, Nueva Ecija Province, Luzon, growing on tree trunks.

The variety is characterized by the complete absence of transverse bars on the sepals and petals. It further differs from the species in its smaller floral segments and leaves.

Genus GASTROCHILUS D. Don

GASTROCHILUS CALCEOLARIS D. Don. Plates 2, 11, and 25.

Gastrochilus calceolaris D. DON, Prodr. Fl. Nep. (1825) 32.

Saccolabium calceolare LINDL. in Wall. Cat. No. 7302, Gen. & Spec. Orch. (1833) 223; Sert. Orch. Frontisp. (1838) No. 6, in Bot. Reg. (1838) Misc. p. 75, No. 139, in Journ. Linn. Soc. **3** (1859) 33; GRIFF., Notul. **3** (1851) 356, Itin. Notes (1848) 170, No. 869, Ic. Pl. Asiat. **3** (1851) *t. 334;* REICHB. f. in Walp. Ann. **6** (1864) 883; HOOK. f., Fl. Brit. Ind. **6** (1890) 60; KING and PANTL. in Ann. Roy. Bot. Gard. Calcutta **8** (1898) 225, *t. 300;* J. J. SM., Fl. Buitenzorg (Orch. Jav.) (1905) 632, Fig.-Atlas (1908) *t. 472* (as *Gastrochilus*).

Äerides calceolare SM. in Rees. Cycl. (1819) Addend. & Corrigend.

Äerides leopardinum WALL. apud Lindl., Sert. Orch. (1838) No. 6, *in synon.*

Gastrochilus sororius SCHLTR. in Fedde. Repert. 12 (1913) 315.

Sarcochilus nepalensis SPRENG. Syst. Veg. **3** (1826) 721.

Epidendrum calceolare BUCH.-HAM. apud D. Don, Prodr. Fl. Nep. (1825) 32, *in synon.*

Gastrochilus philippinensis AMES, Orch. **5** (1915) 231, in MERR. Enum. Philip. Fl. Pl. **1** (1925) 434.

GASTROCHILUS. *Labellum* ventricoso-inflatum, sessile, indivisum, apice appendice rotundatâ papilloso-glandulosâ erosè crenatâ auctum. *Perianthii foliola* omnia distincta, subaequalia, patula. *Columna* brevissima. *Massae pollinis* 2, integrae, sessiles, apici stigmatis adnatae. Herba *arboribus parasitica.* Caudex *brevis, radicans, erectus.* Folia *lineari-lanata, 5–7 pollices longa, 3–5 lineas lata, coriacea, enervia, plana, glabra.* Scapi *brevissimi, ex inferiore caudicis ortum ducentes, vix ibidem aequantes, pluri* (3–5)*-flori.* Pedunculi *patuli, uniflori.* Flores *facie fere* Cypripedii *at minimi.* Perianthii foliola 5, *distincta, obovata, subaequalia.* Labellum *valde ventricosum, foliolis brevius, margine rectum, anticè appendiculatum.*

Obs. Nomen ἀγαδηϱ, *venter*, et χειλος, *labium;* id est *labium ventricosum.*

1. G. calceolaris.

Epidendrum calceolare. *Hamilton MSS.*

Hab. ad Narainhetty Nepalensium, *Hamilton, Wallich.* Floret Februario." Ex. D. Don, Prodr. Fl. Nep. (1825) 32.

"16. *Saccolabium calceolare. Lindl. in Wall. Cat. No. 7302.*

S. subacaule, foliis loratis acuminatis apice obliquè bidentatis, corymbis multifloris breviter pedunculatis, sepalis petalisque obovato-oblongis obtusis, labelli calcare inflato orbiculato; laminâ lunatâ rotundatâ ciliatâ.

Gastrochilus calceolaris *Don Prodr. Nep. 32.* Aeridis calceolare, *Smith in Rees. suppl.* Hab. in *Nepalia* et *Sylhet,* Wallich. (*hab. s. sp. e Mus. Angl. Ind. et v. ic. pict.*). Folia 9 p. longa, basi maculata. Sepala et petala flava, maculis, subrotundis purpureis notata. Labellum album; laminâ basi luteo et coccineo punctatâ." Ex. Lindl., Gen. & Sp. Orch. (1833) 223.

Stems pendulous, about 8 cm long, up to 6 mm in diameter. Roots terete, up to 18 cm long, 3 to 3.5 mm in diameter. Leaves distichous, the lower ones imbricated, light green, oblong, oblong-elliptic, or oblanceolate, narrowed to the very unequally bilobed apex, 14 to 16 cm long, 2.5 to 2.8 cm wide, submembranaceous when dry. Racemes short, corymbose, 3 to 3.5 cm long, 8- to 10-flowered, peduncles green spotted with dark brown, stout and fleshy, 1.3 to 1.5 cm long, provided at the base with two short tubular sheaths which are 3 to 4 mm long. Floral bracts cucullate, ovate, obtuse, rigid, up to 3.5 mm long. Pedicellate ovary reed yellow, 7 to 8 mm long, lined with green. Flowers odorless, crowded, about 1.5 cm across. Sepals and petals fleshy, reed yellow to olive yellow spotted with chocolate on the sepals and brick red on petals. Sepals oblong-obovate, obtuse, about 7 mm long, 4 mm wide at the widest portion. Petals narrower, obovate-spatulate. Labellum 5 to 5.5 mm long, adnate to the lower half of the column, basal portion forming a conical, obtuse sac, 5 to 5.5 mm deep, white blotched with mallow pink, the very tip cream color; lateral lobes inconspicuous, erect; middle lobe subreniform, 3 to 4 mm long, 6 to 7 mm wide, margins deeply and unequally fimbriated, upper surface, except for a V-shaped zinc orange basal callus covered with white hairlike papillæ. At the center of the callus there is a naples yellow ridge. Column very short, stout, white flushed with pink. Anther somewhat flattened, shortly beaked, chartreuse yellow. Pollinia ellipsoid.

LUZON, Manila, Miyasaki Gardens, *Bur. Sci. 82231 Quisumbing,* February 7, 1931. The living plants were collected from Baguio, Benguet Subprovince by Mr. S. Miyasaki, an orchid grower, and are now in cultivation in his gardens. The first Philippine specimen was collected by A. D. E. Elmer 6517 (type of *G. philippinensis* Ames) in Baguio, June 28, 1904. The species has also been reported from Sikkim and the Khasia Hills, Java, Sumatra, and Assam.

After a careful study of this Philippine material, it has been found necessary to reduce *G. philippinensis* Ames to synonymy as the characters relied on for specific distinction have proved to be unreliable.

Genus VANDOPSIS Pfitzer

VANDOPSIS DAVISII sp. nov. Plates 2, 12, 26, and 27.

Herba valida, 20 ad 60 cm alta. Radices elongatae, brunneae, glabrae. Caules teretes, vaginiis foliorum omnino tecta, 1.2 ad 1.5 cm in diametro. Folia disticha, ligulata, valde rigida, falcato-decurvata, 1.5 ad 3.5 cm distantia, ad apicem inaequaliter bilobata cum lobis obtusis, medio canaliculata, 16 ad 39 cm longa, 2.3 ad 3.5 cm lata (in sicco valde coriacea haud nervosa), valde rugosa. Pedunculus 13 ad 14.5 cm longus, 4 ad 5 mm in diametro, rigidus, glaber, erectus. Inflorescentiae racemosae, 10- ad 14-florae, erectae. Pedicellus cum ovario albidus, 2 ad 2.5 cm longus, rigidus, glaber. Bracteae inflorescentiae squamiformes, breves, ovatae, cucullatae, circiter 3 mm longae; bracteae caulinae tubulares, 3 ad 4 mm longae. Flores albido-virides, 2.2 ad 2.4 cm lati, 3.2 ad 3.3 cm longi, carnosi. Sepala breviter unguiculata. Sepala lateralia ovato-elliptica, obtusa, circiter 1.5 cm longa, 7 mm lata. Sepalum dorsale ovato-oblanceolatum, obtusum, circiter 1.6 cm longum, supra medium 7 mm latum. Petala oblanceolata, obtusa, circiter 1.4 cm longa, 5.5 ad 6 mm lata. Labellum trilobatum, base valde saccata, circiter 1.1 cm longum; lobi laterales parvi, erecti, triangulares, circiter 2 mm alti, late rotundati, carnosi, utrinque glabri; lobus medius multo major, carnosus, lateraliter compressus, rigidus, in circuitu (supra visus) ovato-lanceolatus, circiter 7 mm longus, subtus prominenter carinatus, supra minutissime pubescens, apice truncatus. Carina transversa suborbicularis valde concava in basi saccata stat. Gynostemium breve, crassum, circiter 6 mm longum glabrum, ad apicem biconnutum. Anthera glabra. Pollinia 4, subaequalia. Capsula ellipsoidea, valde saccata, 6 ad 6.5 cm longa, 1.7 ad 1.8 cm in diametro.

A very coarse herb, 20 to 60 cm high, recalling *Sarcanthus pachyphyllus* Ames. Roots elongate, brown, glabrous. Stems terete, coarse, very rigid, usually erect, sometimes curved, altogether concealed by the tubular leaf-sheaths, 1.2 to 1.5 cm in diameter. Leaves distichous, ligulate, 16 to 39 cm long, 2.3 to 3.5 cm wide, very rigid, very thickly leathery, falcate-decurved, in texture approaching those of *Sarcanthus pachyphyllus,* 1.5 to 3.5 cm distant, unequally bilobed at the apex with obtuse lobes, channelled through the middle (when dry very coriaceous and never nerved), very rugose. Peduncles erect, rigid, 13 to 14.5 cm long, 4 to 5 mm in diameter, glabrous. Inflorescences in the upper part of the peduncle, racemose, 10- to 14-flowered, erect. Pedicellate ovary white, 2 to 2.5 cm long, rigid, glabrous, twisted at the base. Bracts of the inflorescence squamiform, short, ovate, cucullate, about 3 mm long. Flowers fragrant, fleshy, firm, 2.2 to 2.4 cm across, 3.2 to 3.3 cm long. Sepals shortly clawed. Lateral sepals ovate-elliptic, obtuse, about 1.5 cm long, 7 mm wide. Dorsal sepal ovate-oblanceolate, obtuse, about 1.6 cm long, 7 mm wide about the middle. Petals oblanceolate, obtuse, about 1.4 cm long, 5.5 to 6 mm wide. Labellum trilobed, conspicuously saccate at the base, about 1.1 cm long; lateral lobes small, erect, triangular, about 2 mm high, broadly rounded, fleshy, glabrous on both surfaces; middle lobe much larger, fleshy, laterally compressed, in outline (when seen from above) ovate-lanceolate, rigid, about 7 mm long, prominently carinate beneath, very minutely pubescent above, truncate at the apex. At the saccate base of the labellum (between the lateral lobes) there is a small transverse, suborbicular, deeply concave keel as in *Staurochilus ionosma.* Gynostemium short, stout, about 6 mm long, glabrous, 2-horned at the apex with falcate horns. Anther glabrous. Pollinia 4, subequal. Capsules ellipsoid, 6 to 6.5 cm long, 1.7 to 1.8 cm in diameter, prominently 3-keeled (between each keel there are two shallow ridges).

LUZON, Manila Bureau of Science orchid house, *Bur. Sci. 82228 Quisumbing,* March 31, 1931. The living plants, according to orchid peddlers, were originally collected from the mountains near Montalban, Rizal Province, Luzon. They are now in cultivation in the Bureau of Science orchid house, Miyasaki Gardens, and Mrs. Remedios C. Gonzales's gardens, all in Manila. Rachis of the inflorescence greenish; pedicellate ovary white; sepals and petals white on back and front washed with lumiere green or light lumiere green, and spotted and barred with claret brown on the petals and raw umber on the sepals; lateral lobes of the labellum pale viridine yellow; middle lobe of the labellum white; spotted with ox-blood red above, on both sides of the keel above and empire yellow at the very tip of the tongue; callus at the base of the labellum between the lateral lobes cuplike, white, light orange yellow within.

In habit this unique species suggests *Sarcanthus pachyphyllus*, especially in the very rigid, thick, keeled, falcate leaves, but it differs radically in floral characters. In floral structure it is very much like *Vandopsis lissochiloides* (Gaudich.) Pfitz., but its flowers are much smaller and of different color.

This very interesting species is dedicated to Hon. Dwight F. Davis, for his interest in orchids and particularly for his unselfish devotion and interest in his work when Governor-General of the Philippines.

Genus MICROSACCUS Blume

MICROSACCUS WENZELII Ames. Plates 1, 13, and 28.

Microsaccus Wenzelii AMES Orch. 5 (1915) 257, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 442.

Planta pusilla, epiphytica. Radices in basi caulium. Caules dependentes (?) usque ad 1 dm. alti, circiter 3 mm. in crassitudine, cum foliis usque ad 4 cm. lati, vaginis foliorum persistentibus obtegentibus: internodia brevia vaginis omnino tecta, 3 mm. longa. Folia biseriata, patentissima, equitantia, crasse carnosa, lateraliter compressa, oblonga a latere visa, dorso et apice acutangula, obtusa sed a basi sensim angustata, in sicco valde rugosa, usque ad 2 cm. longa, circiter 5 mm. alta, supra canaliculata. Inflorescentiae axillares, brevissimae, 1 (-2) florae. Pedunculus folii vaginis aequilongus. Bracteae ovatae vel orbiculares, valde concavae, extus leviter carinatae, membranaceae, usque ad 5 mm. longae. Flores parvi, albi. Sepala lateralia leviter falcata, obtusa, extus, prope apicem, carinata, trinervia, vix 5 mm. longa, 2 mm. lata. Sepalum dorsale sepalis lateralibus minus, ad apicem cucullatum et incrassatum vel carinatum, 4 mm. longum, 1.5 mm. latum, trinervium. Petala oblongi-lanceolata, uninervia, obtusa, 3 mm. longa, 1 mm. lata. Labellum calcaratum, spathulatum vel cuneato-obovatum, ad apicem obscure trilobatum, in disco bicallosum. Lamina incrassata cum calcari 7 mm. longa, ad apicem 3 mm. lata. Calcar circiter 2 mm. longum, scrotiforme, emarginatum. Gynostemium brevissimum. Fructus 7 mm. longus.

Epiphyte. Stems curved in maturity, the base terete, leafless, but covered with remnants of sheaths, the apical portion foliose, up to 11.5 cm long. Roots fibrous, numerous. Leaves conspicuously and densely distichous, equitant, imbricating, sessile, lanceolate, obtuse, decreasing but little in size toward the apex, the largest up to 2 cm long, 6 mm wide, rigid, leathery, thick, flattened, rugose when dry; internodes very short. Flowers small, white, single in the axils of the leaves, about 8 mm across. Pedicellate ovary very slender, about 1.5 mm long, entirely covered by imbricated, triangular, acute bracts which are 3.5 to 4 mm long. Lateral sepals obliquely elliptic, slightly falcate, obtuse, about 5 mm long, 2.5 mm wide. Dorsal sepal narrowly oblong, obtuse, about 5 mm long, 1.75 mm wide, 3-nerved. Petals oblong-lanceolate, obtuse, about 4 mm long, 1.5 mm wide. Labellum simple, obovate, fleshy, about 4 mm long, obscurely trilobed, apex expanded, 2 mm wide, subacute, the very apex thickened beneath. Spur short, flattened, emarginate, about 2.5 mm long. Column very minute, about 1 mm long.

LUZON, Manila, Bureau of Science orchid house, *Bur. Sci. 82230 Quisumbing,* January 24, 1931. The living plants were originally gathered by Mr. Maximo Ramos, botanical collector of the Bureau of Science, at Quezon National Park, Tayabas Province, growing on tree trunks. LEYTE, Dagami, *C. A. Wenzel, 0159, 029,* October 25, 1912 (type).

This species is closely related to *Microsaccus brevifolius* J. J. Sm., differing in habit and in the form of the sepals and petals.

ILLUSTRATIONS

PLATE 1

FIG. 1. ***Microsaccus Wenzelii*** Ames, front view of a flower, × 2.
2. ***Microsaccus Wenzelii*** Ames, side view of a flower, × 2.
3. ***Coelogyne Remediosae*** sp. nov., front view of a flower, × 1.
4. ***Coelogyne Remediosae*** sp. nov., side view of a flower, × 1.
5. ***Agrostophyllum saccatilabium*** sp. nov., front view of a flower, × 4.
6. ***Agrostophyllum saccatilabium*** sp. nov., side view of a flower, × 4.
7. ***Dendrobium Guerreroi*** sp. nov., front view of a flower, × 1.
8. ***Dendrobium Guerreroi*** sp. nov., side view of a flower, × 1.
9. ***Dendrobium auriculatum*** sp. nov., front view of a flower, × 1.
10. ***Dendrobium auriculatum*** sp. nov., side view of a flower, × 1.
11. ***Dendrochilum Weberi*** Ames, front view of a flower, × 4.
12. ***Dendrochilum Weberi*** Ames, side view of a flower, × 4.
13. ***Sarcochilus benguetensis*** sp. nov., front view of a flower, × 2.
14. ***Sarcochilus bneguetensis*** sp. nov., side view of a flower, × 2.

PLATE 2

FIG. 1. ***Gastrochilus calceolaris*** D. Don, front view of a flower, × 2.
2. ***Gastrochilus calceolaris*** D. Don, side view of a flower, × 2.
3. ***Gastrochilus calceolaris*** D. Don, view of column, anther and labellum from above, × 4.
4. ***Cymbidium pubescens*** Lindl., front view of a flower, × 1.
5. ***Cymbidium pubescens*** Lindl., side view of a flower, × 1.
6. ***Phalaenopsis Lueddemanniana*** Reichb. f. var. ***purpurea*** var. nov., front view of a flower, × 1.
7. ***Phalaenopsis Lueddemanniana*** Reichb. f. var. ***purpurea*** var. nov., side view of a flower, × 1.
8. ***Vandopsis Davisii*** sp. nov., front view of a flower, × 1.
9. ***Vandopsis Davisii*** sp. nov., side view of a flower, × 1.
10. ***Vandopsis Davisii*** sp. nov., front view of ovary, column and labellum, × 2.
11. ***Vandopsis Davisii*** sp. nov., side view of column and labellum, × 2.

PLATE 3

Coelogyne Remediosae sp. nov.: *1*, dorsal sepal, × 2; *2*, lateral sepal, × 2; *3*, petal, × 2; *4*, labellum and column from above, × 2; *5*, side view of column and labellum, × 2; *6*, front view of column, × 2; *7*, view of anther from above, × 17; *8*, view of anther from below, × 17; *9*, side view of anther, × 17; *10*, two pollinia, × 17.

PLATE 4

Dendrochilum Weberi Ames: *1*, dorsal sepal, × 16; *2*, lateral sepal, × 16; *3*, petal, × 16; *4*, view of column and labellum from above (natural position), × 28; *5*, side view of column and labellum, × 28; *6*, view of labellum (expanded) from above × 36; *7*, front view of column, × 28; *8*, views of anther from above and from below, × 36; *9*, pollinia, × 28.

PLATE 5

Agrostophyllum saccatilabium sp. nov.: *1*, a spike showing floral bracts and buds, × 4; *2*, a floral bract, × 15; *3*, dorsal sepal viewed from within, × 12; *4*, lateral sepal viewed from without, × 12; *5*, outer view of petal, × 12; *6*, side view of column, and labellum, × 12; *7*, view of labellum from above (in natural position), × 12; *8*, front view of column with the labellum removed, × 12; *9*, view of anther from above, × 34; *10*, pollinia, × 52.

PLATE 6

Dendrobium auriculatum sp. nov.: *1*, portion of the stem with leaves, × 0.5; *2*, detail of the base of the leaf and its attachment, × 2; *3*, dorsal sepal, × 1; *4*, lateral sepal, spur, and pedicellate ovary, × 1; *5*, petal, × 1; *6*, view of column and labellum from above (natural position), × 1; *7*, view of labellum (expanded) from above, × 1; *8*, side view of ovary, column, spur, and labellum (natural position), × 1; *9*, front view of column with foot, × 2; *10*, side view of pedicellate ovary, column, and spur with lateral sepals removed, × 2; *11*, view of anther from above, × 6; *12*, view of anther from below, × 6; *13*, pollinia, × 6.

PLATE 7

Dendrobium Guerreroi sp. nov.: *1*, dorsal sepal, × 2; *2*, lateral sepal and pedicellate ovary, × 2; *3*, petal, × 2; *4*, side view of ovary, column, and labellum, × 2; *5*, front view of column and labellum (natural position), × 2; *6*, view of (extended) labellum from above, × 2; *7*, side view of ovary and column with anther, × 4; *8*, front view of column with foot, × 4; *9*, view of anther from above, × 12; *10*, view of anther from below, × 12; *11*, two pollinia, × 12.

PLATE 8

Cymbidium pubescens Lindl.: *1*, dorsal sepal, × 3; *2*, petal, × 3; *3*, lateral sepal, × 3; *4*, view of column and expanded labellum from above, × 4; *5*, side view of portion of ovary, column, and labellum, (natural position), × 4; *6*, view of anther from above, × 15; *7*, view of anther from below, × 15; *8*, pollinia, × 30.

PLATE 9

Sarcochilus benguetensis sp. nov.: *1*, dorsal sepal, × 12; *2*, lateral sepal, × 12; *3*, petal, × 15; *4*, side view of column, labellum and spur, × 12; *5*, view of labellum with side lobes expanded from above, × 8; *6*, front view of column and anther, × 15; *7*, view of anther from below, × 28; *8*, pollinia, × 28.

PLATE 10

Phalaenopsis Lueddemanniana Reichb. f. var. *purpurea* var. nov.: *1*, dorsal sepal, × 2; *2*, petal, × 2; *3*, lateral sepal, × 2; *4*, view of column and labellum from above (natural position), × 4; *5*, view of labellum (expanded) from above, × 4; *6*, side view of column and labellum (natural position), × 4; *7*, views of anther from below and from above, × 5; *8*, pollinia, × 6.

PLATE 11

Gastrochilus calceolaris D. Don: *1*, dorsal sepal, × 4; *2*, petal, × 4; *3*, lateral sepal, × 4; *4*, side view of column and labellum, × 7; *5*, view of column and labellum from above, × 7; *6*, view of anther from above, × 15; *7*, view of anther from below, × 15; *8*, two pollinia, × 28.

PLATE 12

Vandopsis Davisii sp. nov.: *1*, dorsal sepal, × 3; *2*, petal, × 3; *3*, lateral sepal, × 3; *4*, side view of portion of ovary, column with anther and labellum, × 5; *5*, front view of column, and labellum, × 5; *6*, view of labellum from above with the lateral lobes slightly expanded, × 5; *7*, view of anther from above, × 15; *8*, view of anther from below, × 15; *9*, pollinia, × 15; *10*, fruit, × 1.

PLATE 13

Microsaccus Wenzelii Ames: *1*, habit of the plant with one flower, × 1; *2*, dorsal sepal, × 7.5; *3*, lateral sepal, × 7.5; *4*, petal, × 7.5; *5*, side view of ovary, column, and labellum, × 7.5; *6*, view of spur, column with anther removed, and labellum from above, × 7.5; *7*, view of anther from above, × 13; *8*, view of anther from below, × 13; *9*, pollinia, × 11.

PLATE 14

Coelogyne Remediosae sp. nov.: habit, very much reduced, and flower, reduced.

PLATE 15

FIG. 1. *Dendrochilum Weberi* Ames: habit, very much reduced.
2. *Dendrochilum Weberi* Ames: flowers and portion of plant, very slightly enlarged.

PLATE 16

Agrostophyllum saccatilabium sp. nov.: habit, very much reduced.

PLATE 17

Agrostophyllum saccatilabium sp. nov.: inflorescence and leaf-bases, slightly enlarged.

PLATE 18

FIG. 1. *Dendrobium auriculatum* sp. nov.: habit, very much reduced.
2. *Dendrobium auriculatum* sp. nov.: flower, slightly enlarged.

PLATE 19

Dendrobium Guerreroi sp. nov.: habit, very much reduced.

PLATE 20

Dendrobium Guerreroi sp. nov.: flowers, slightly reduced.

PLATE 21

Cymbidium pubescens Lindl.; habit, very much reduced.

PLATE 22

Cymbidium pubescens Lindl.; flowers and raceme, almost natural size.

PLATE 23

Sarcochilus benguetensis sp. nov.; habit, very much reduced.

PLATE 24

FIG. 1. *Phalaenopsis Lueddemanniana* Reichb. f. var. *purpurea* var. nov.; habit, very much reduced.
2. *Phalaenopsis Lueddemanniana* Reichb. f. var. *purpurea* var. nov.; flower, slightly enlarged.

PLATE 25

Gastrochilus calceolaris D. Don; habit, much reduced.

PLATE 26

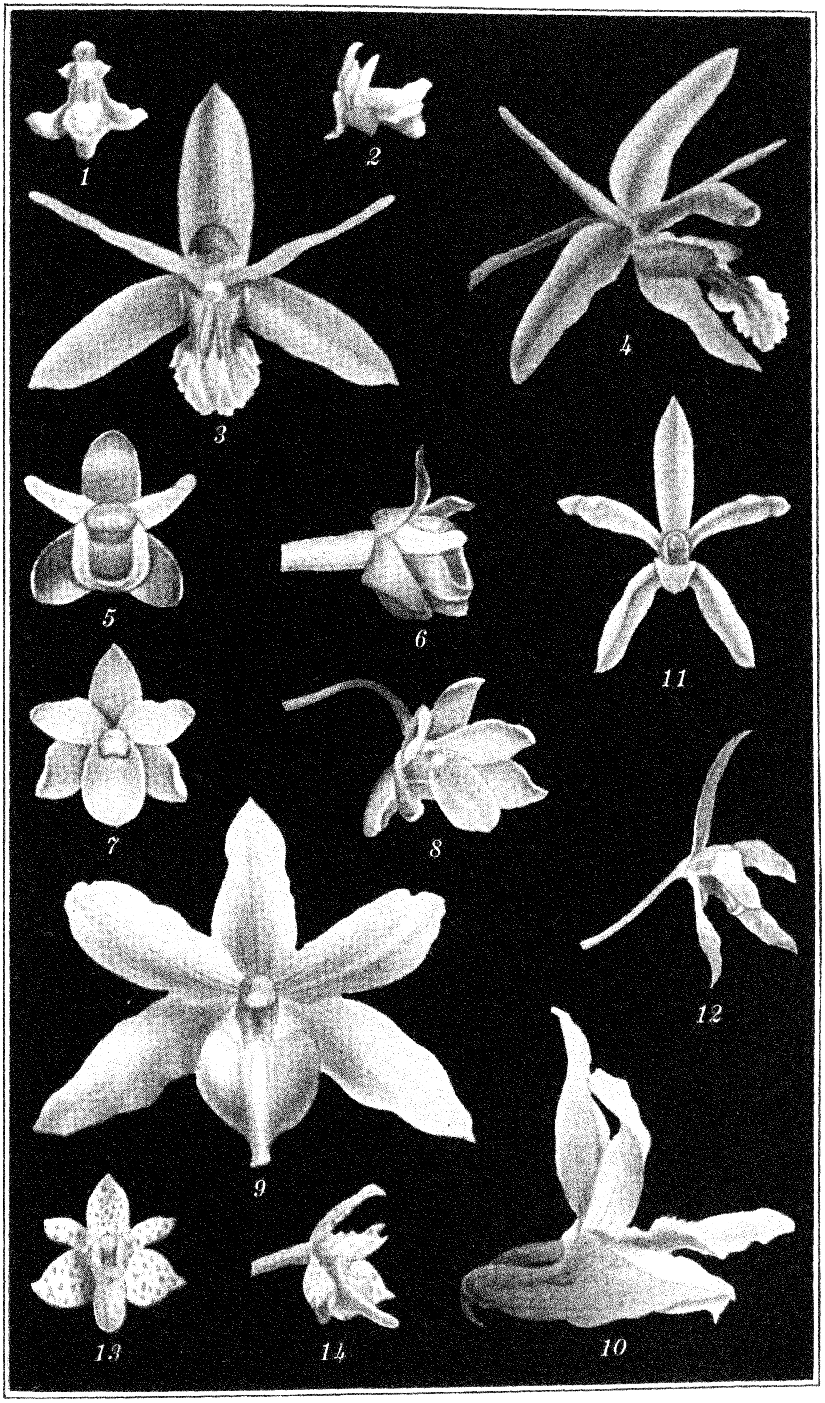
Vandopsis Davisii sp. nov.; habit, very much reduced.

PLATE 27

Vandopsis Davisii sp. nov.; flowering raceme, slightly reduced.

PLATE 28

FIG. 1. *Microsaccus Wenzelii* Ames; habit, very slightly enlarged.
2. *Microsaccus Wenzelii* Ames; tops of plants, each with a flower, enlarged about thrice natural size.



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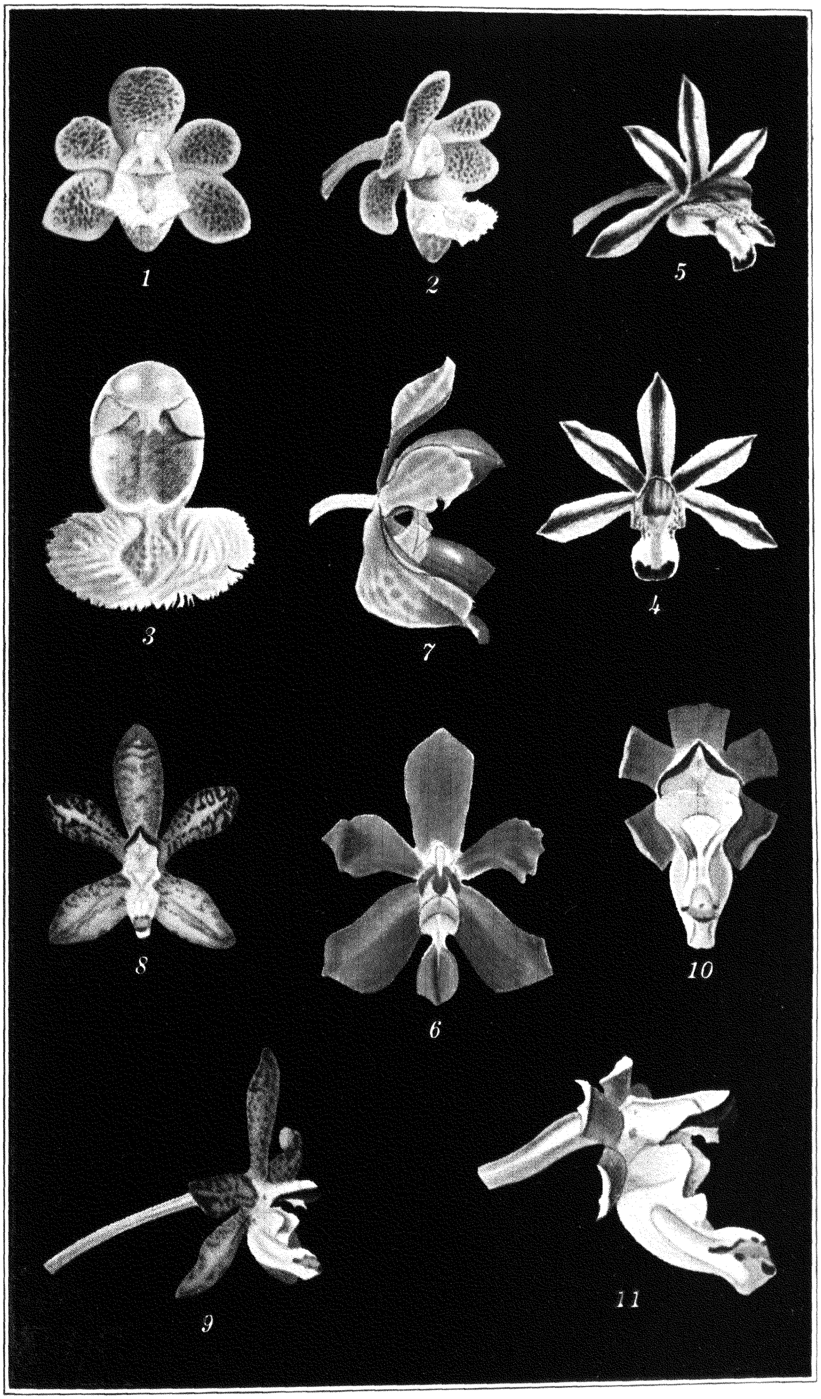

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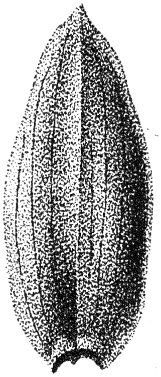
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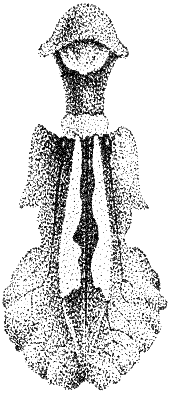
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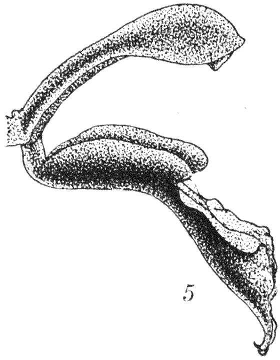
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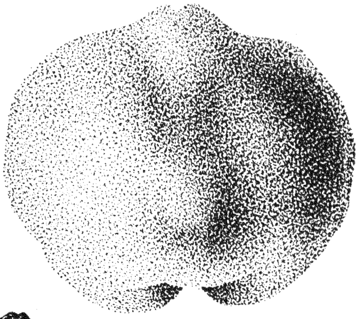
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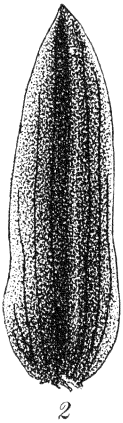
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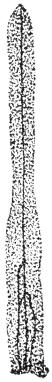
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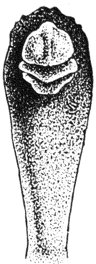
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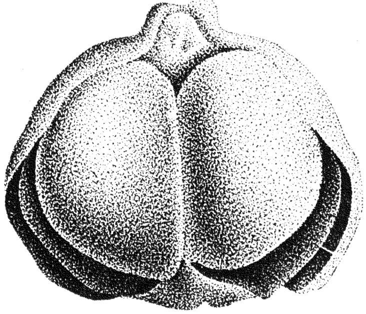
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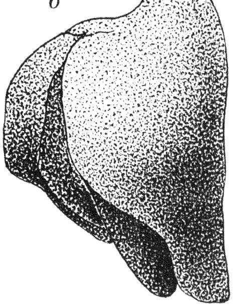
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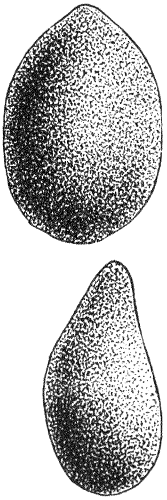
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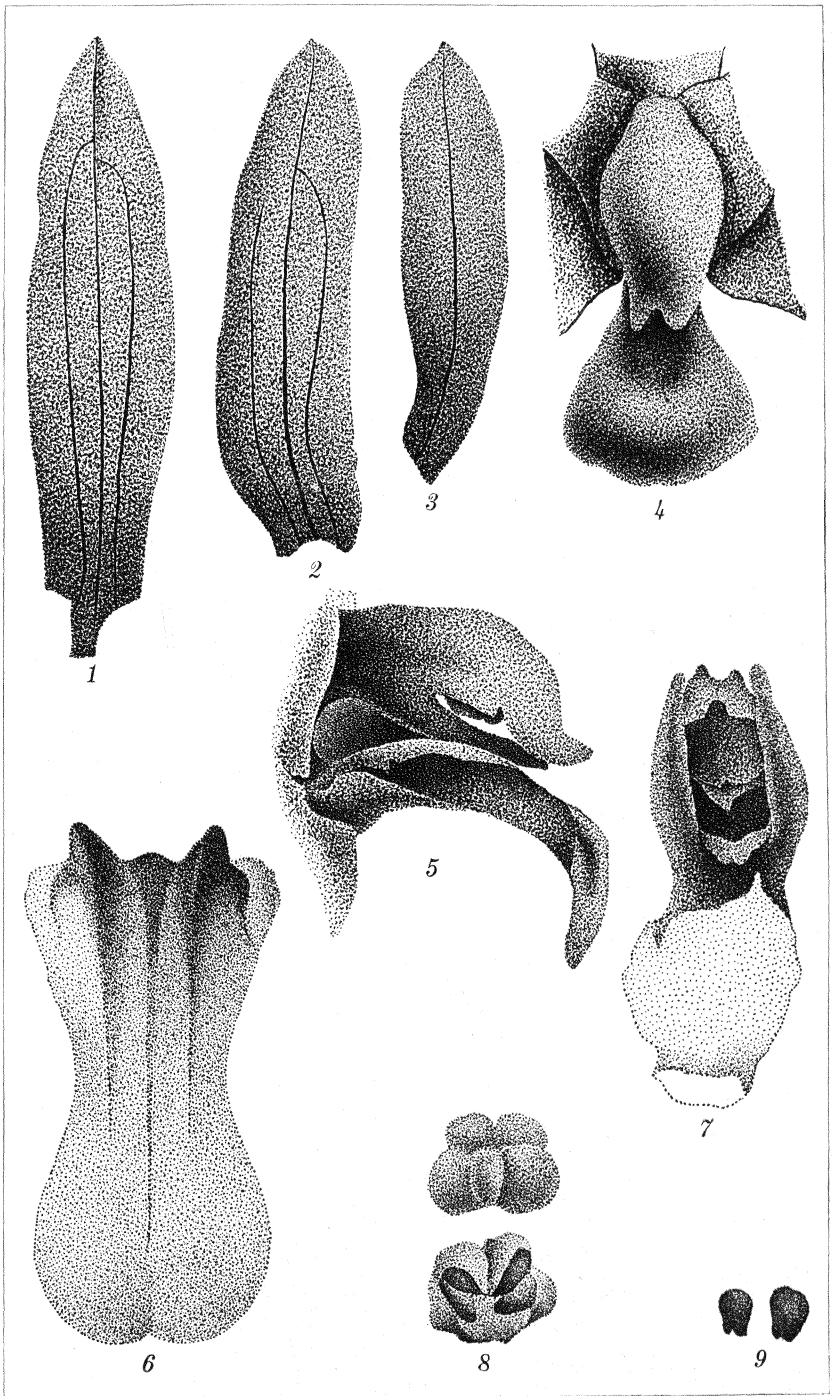

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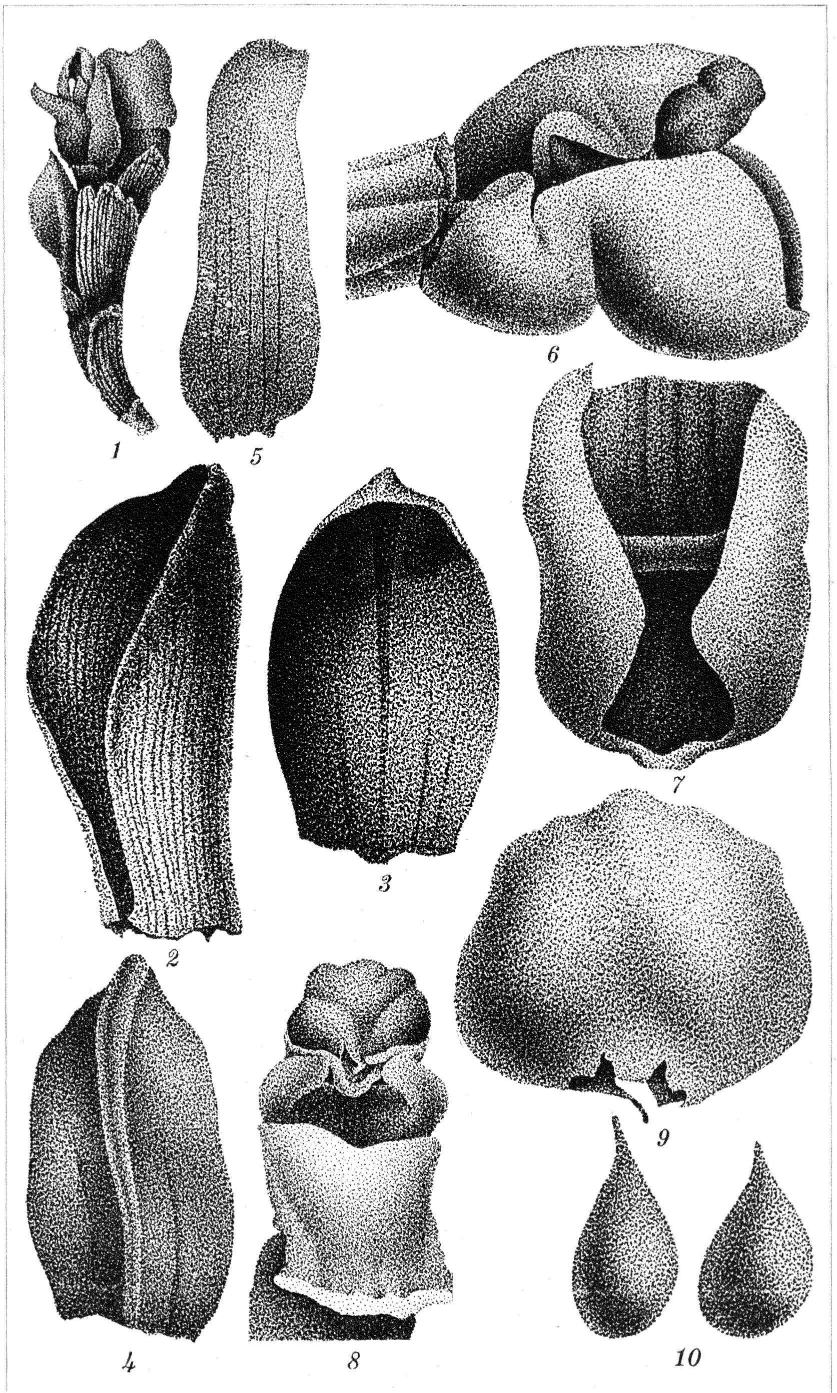

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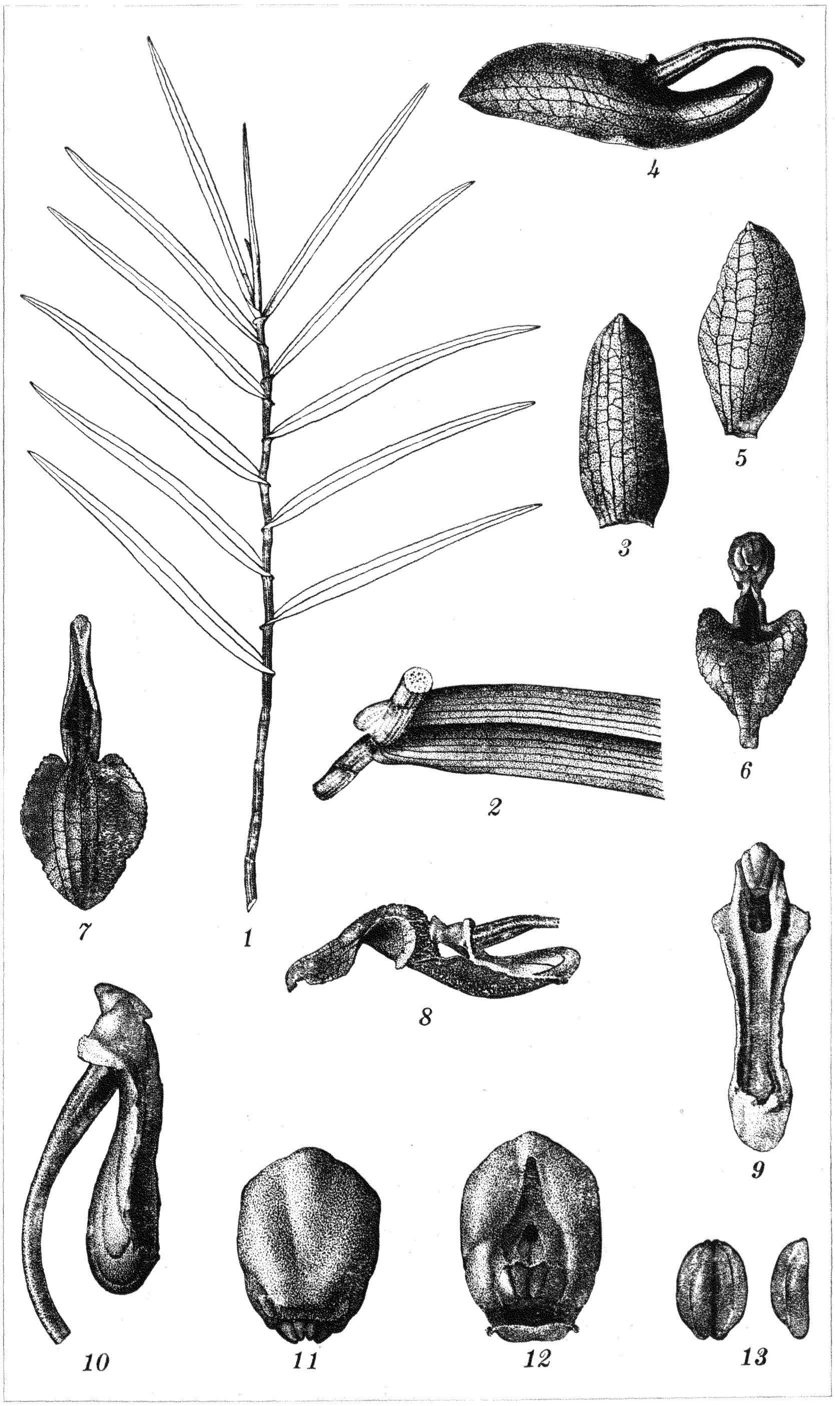

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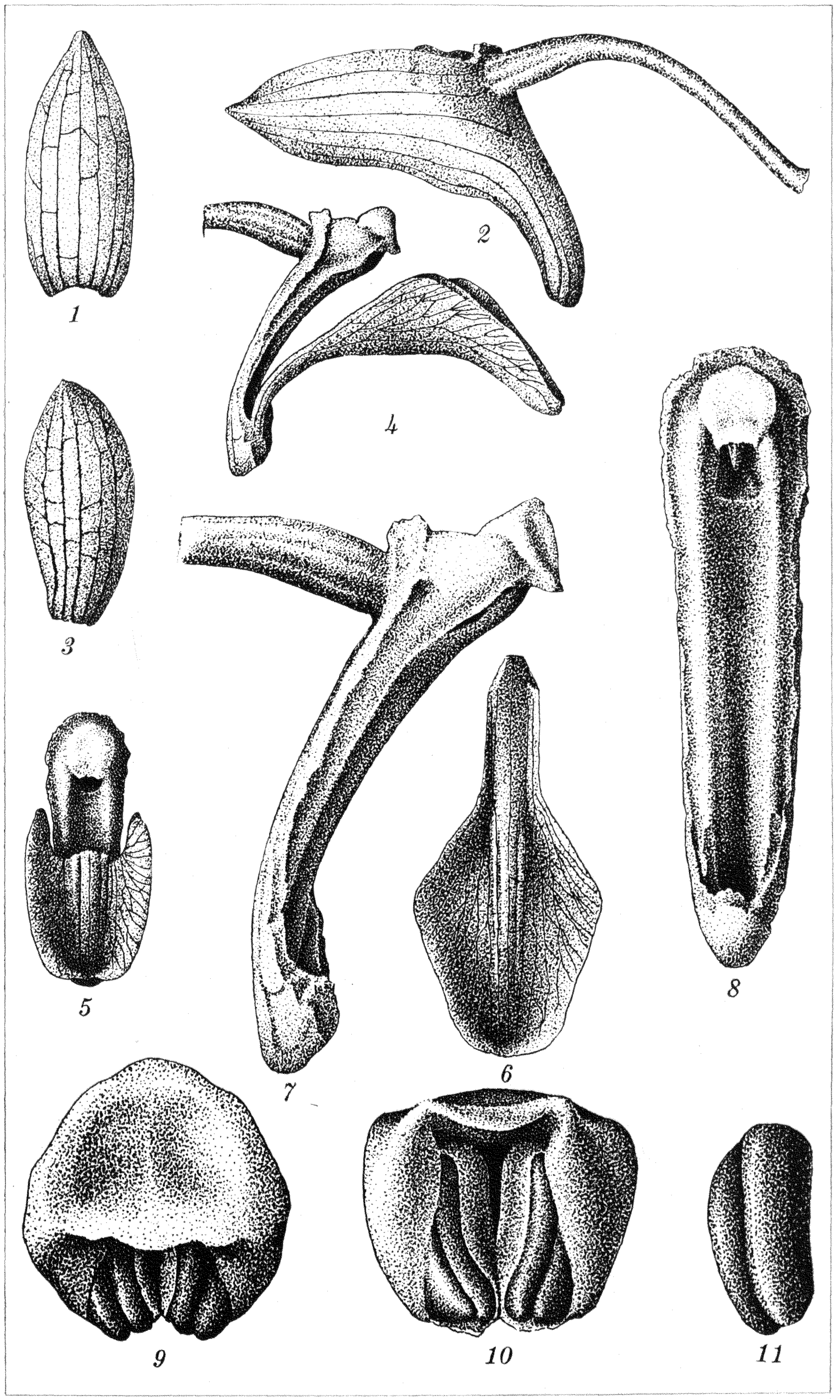

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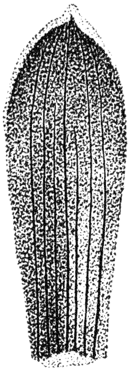

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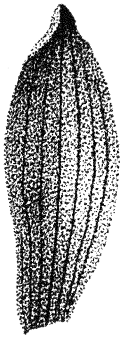

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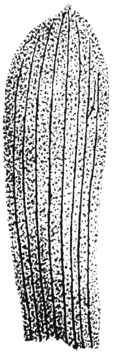

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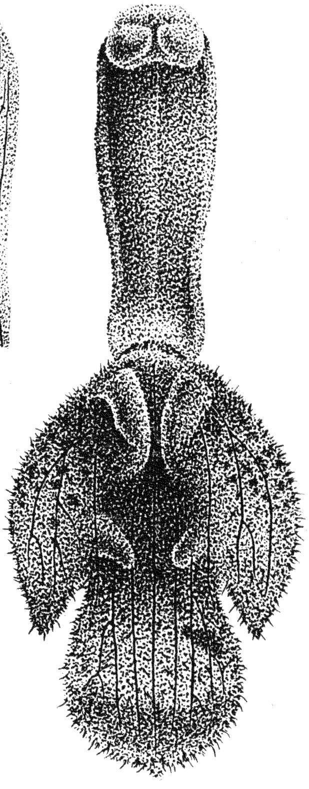

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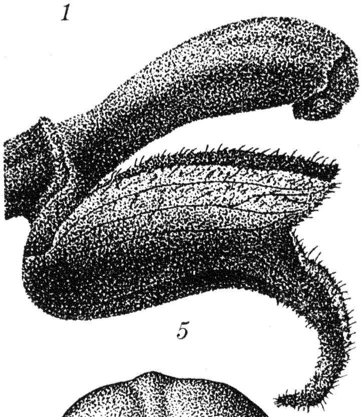

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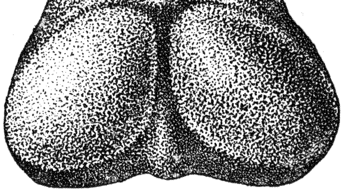

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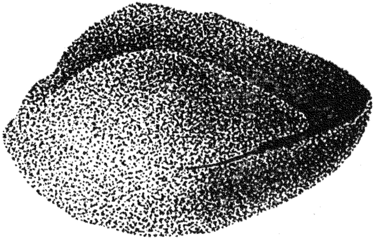

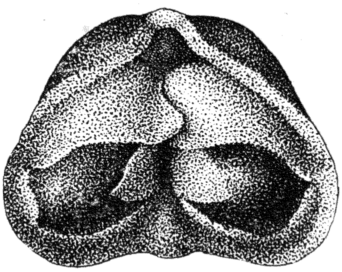

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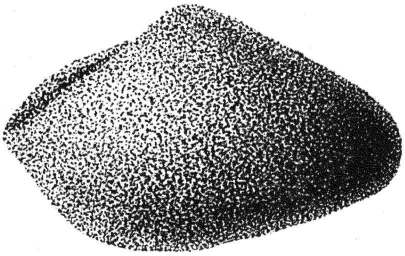

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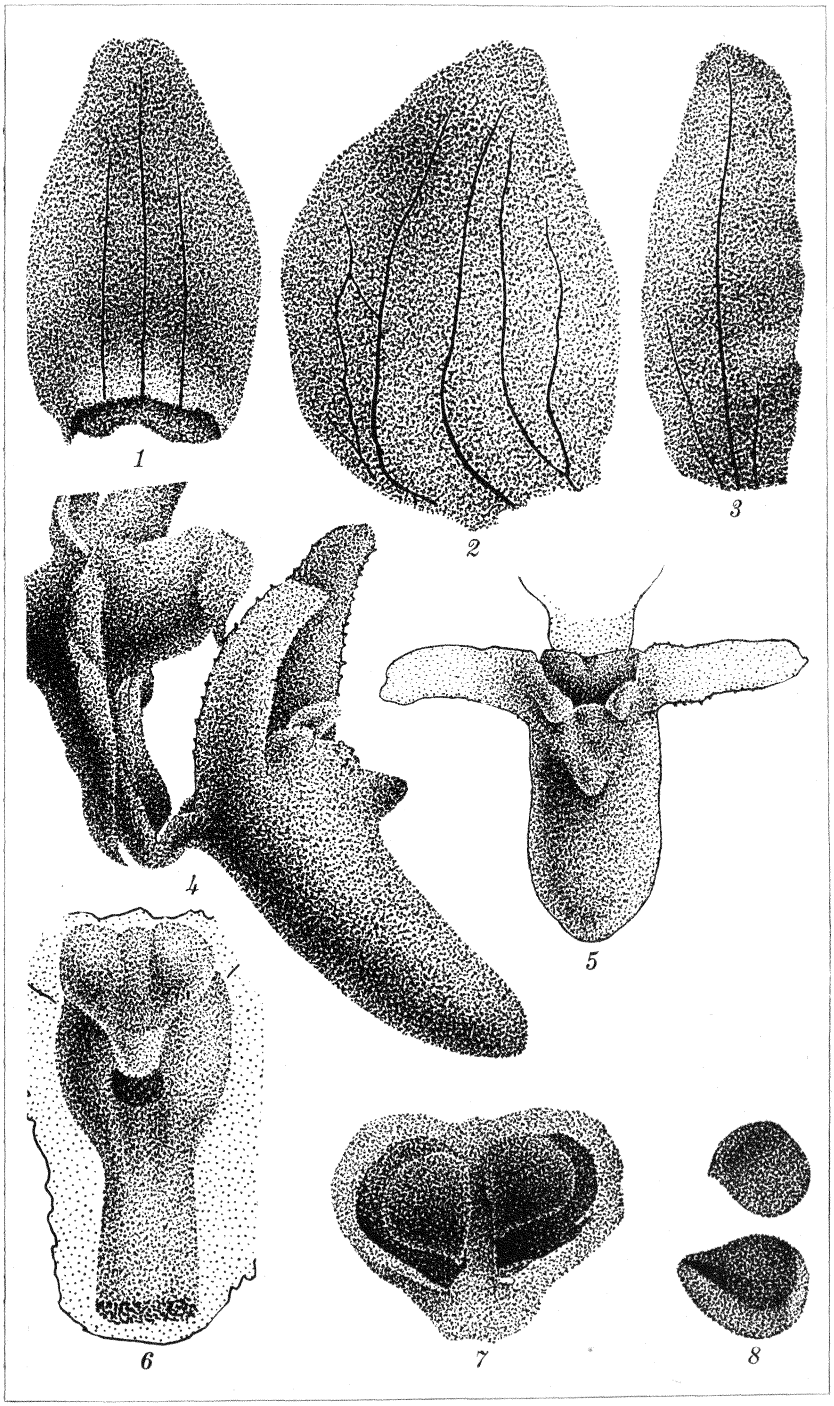

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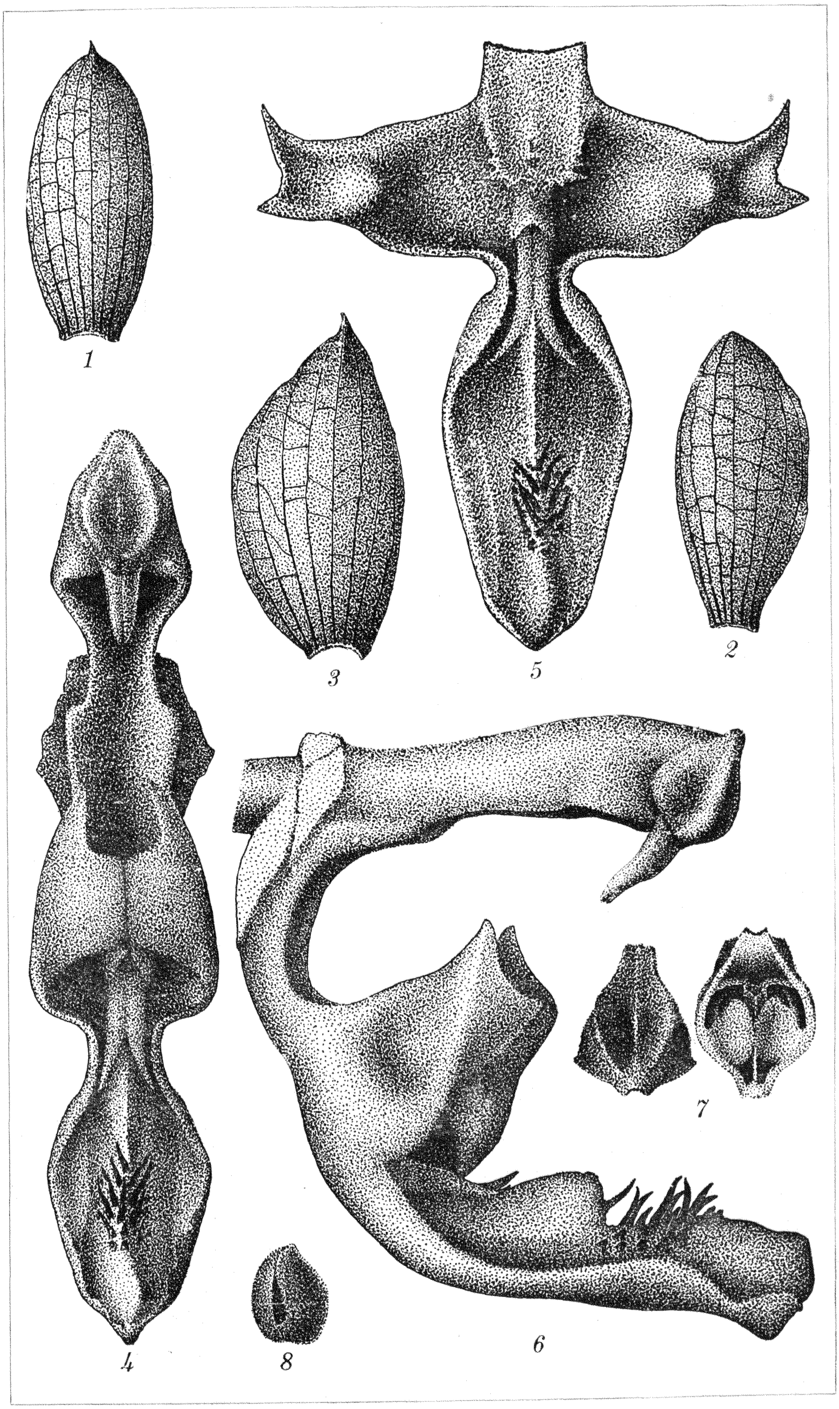

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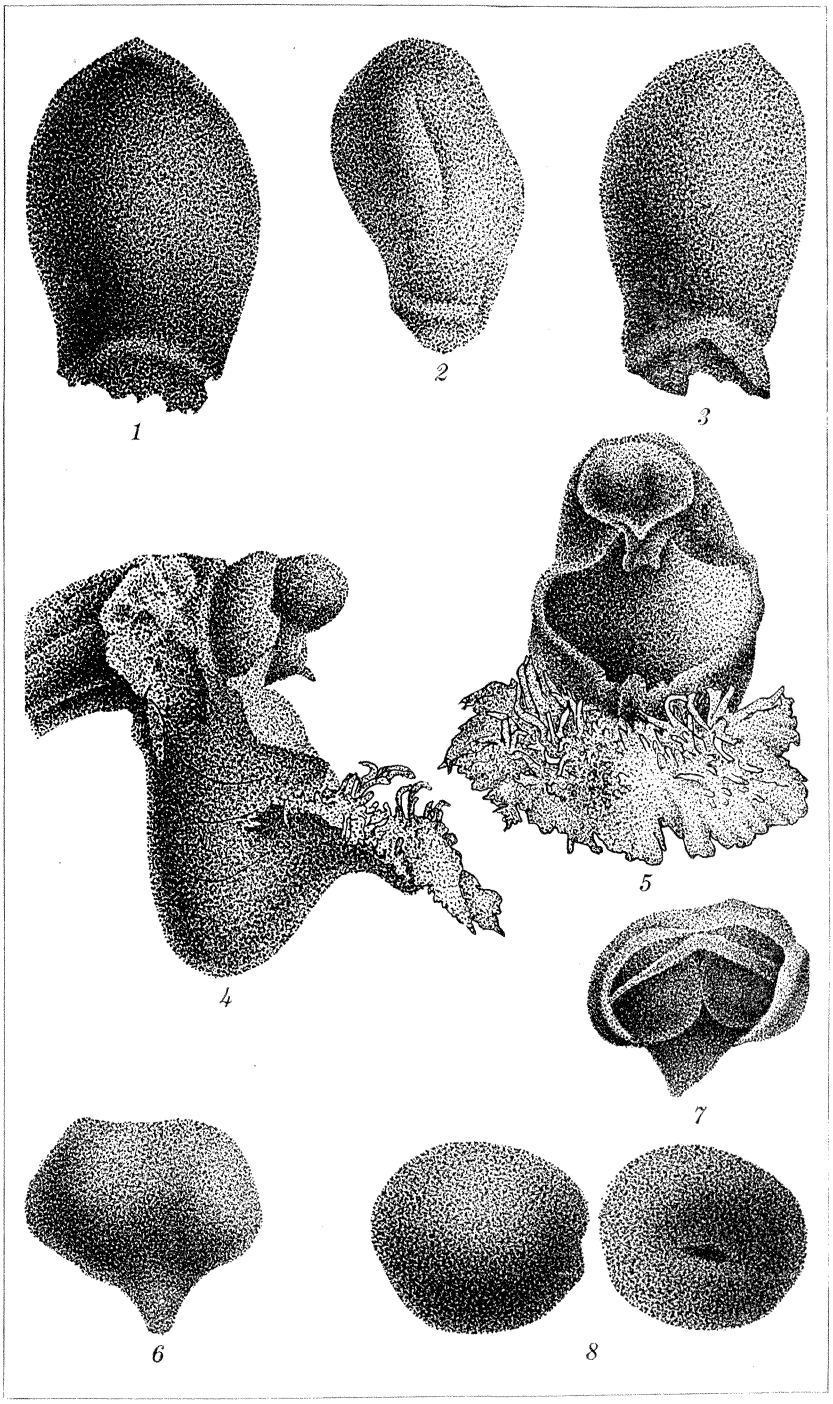

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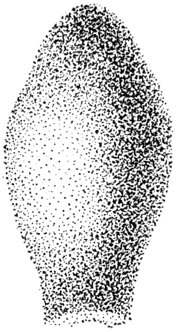
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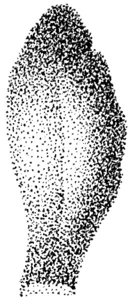
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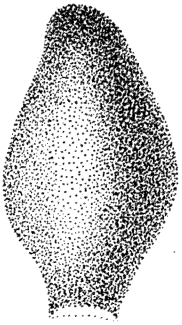
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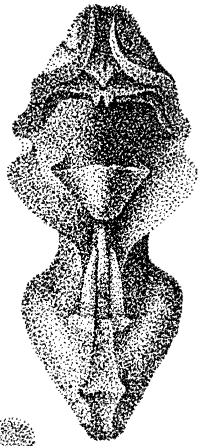
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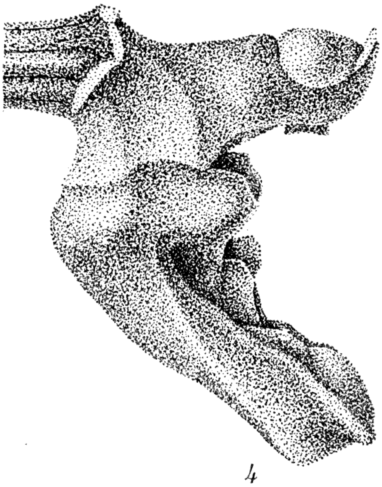
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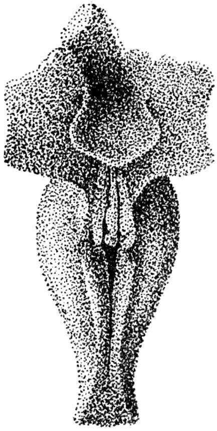
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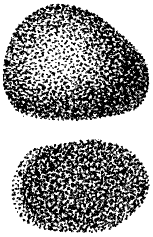
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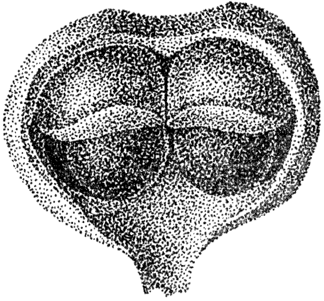
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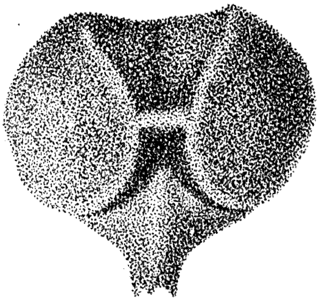
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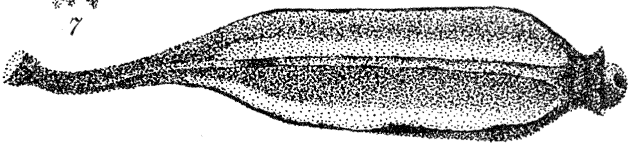
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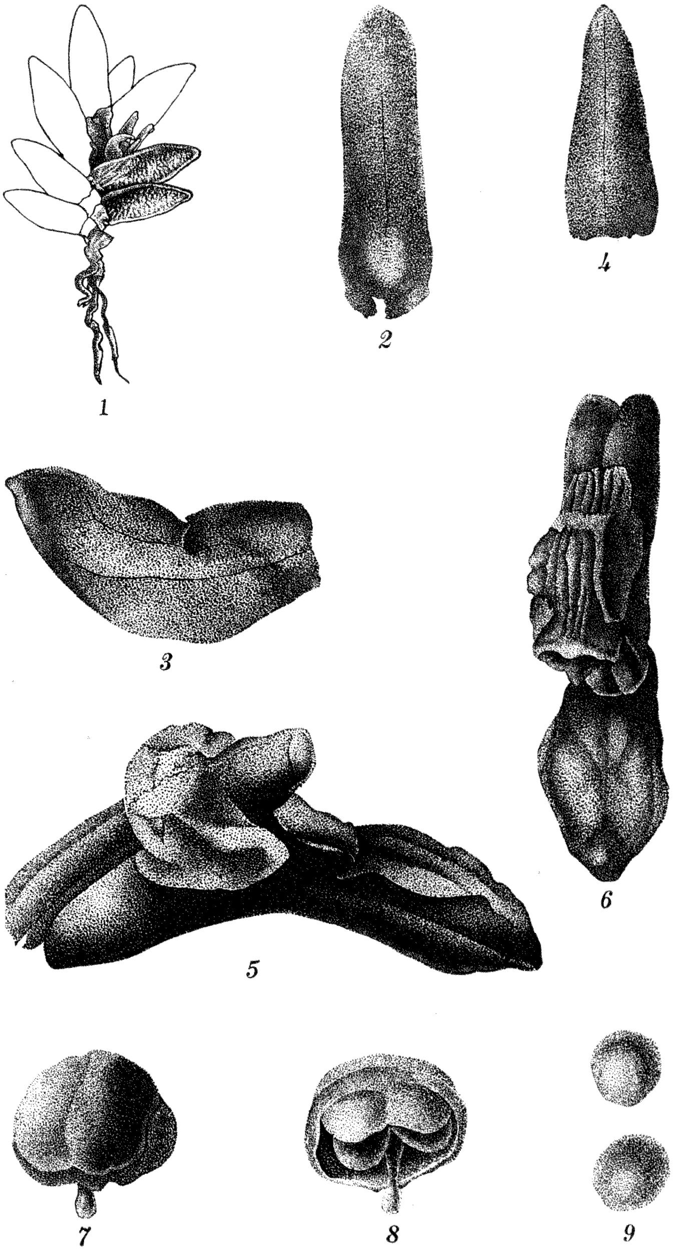

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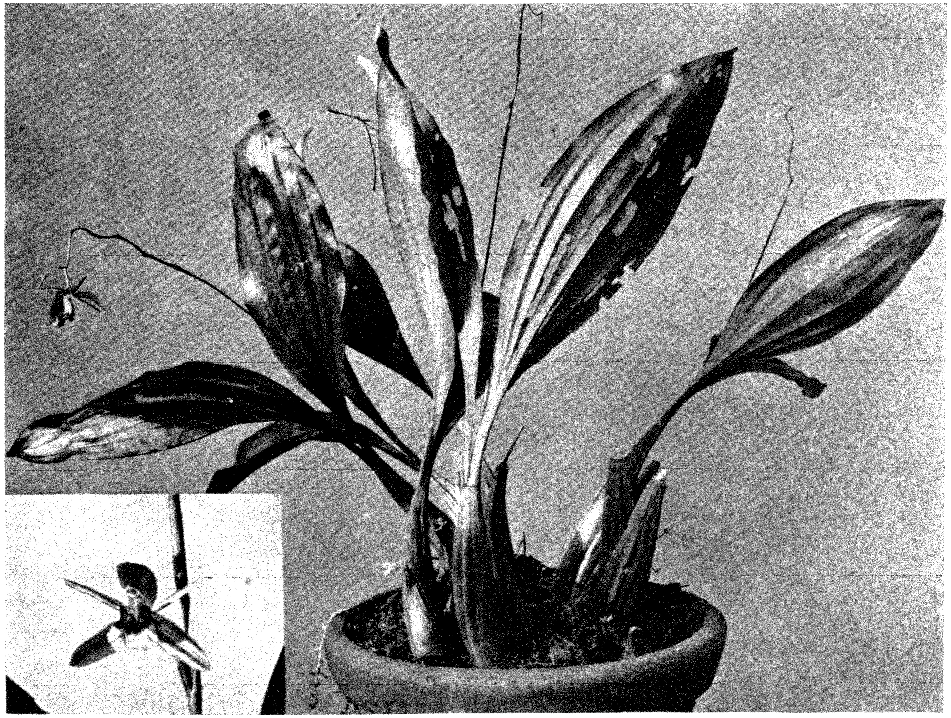

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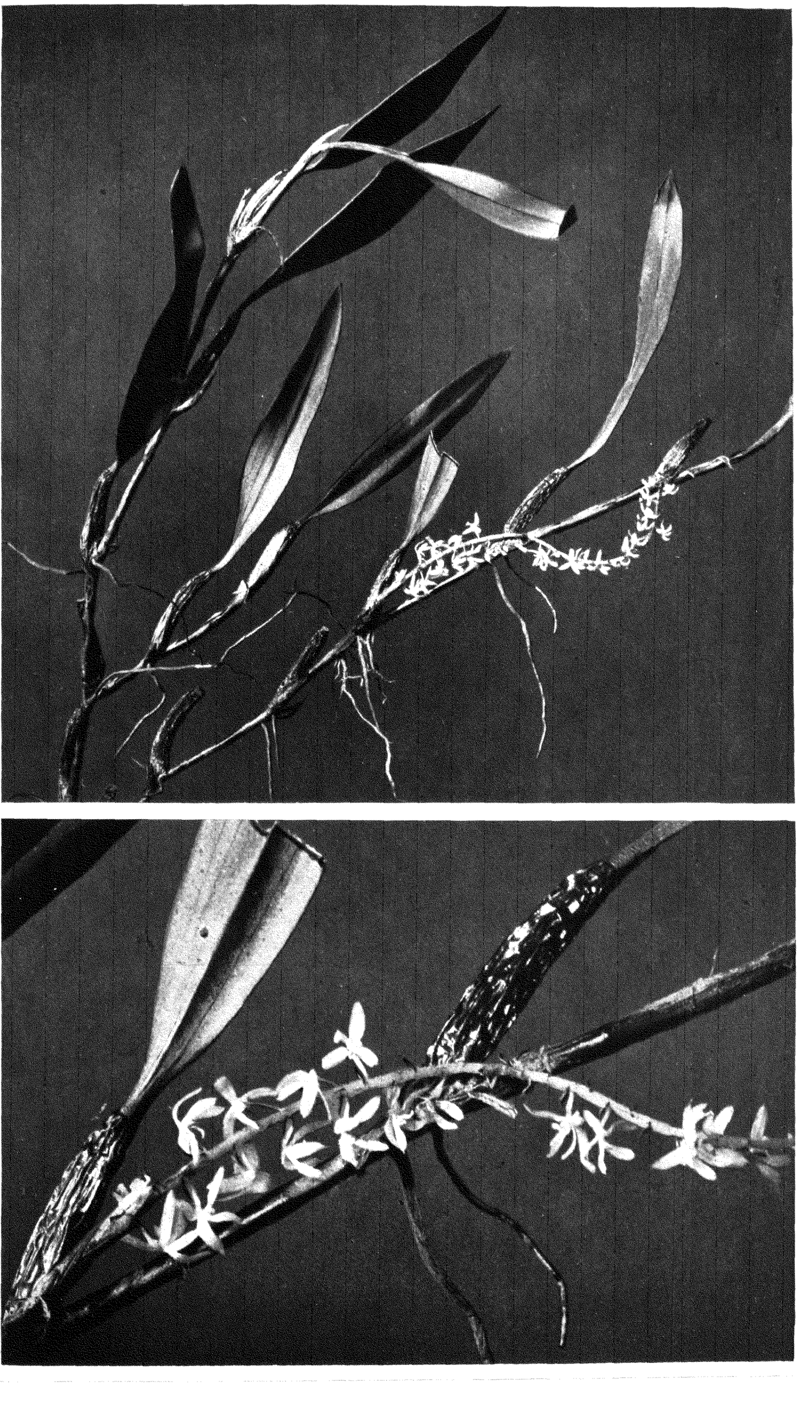

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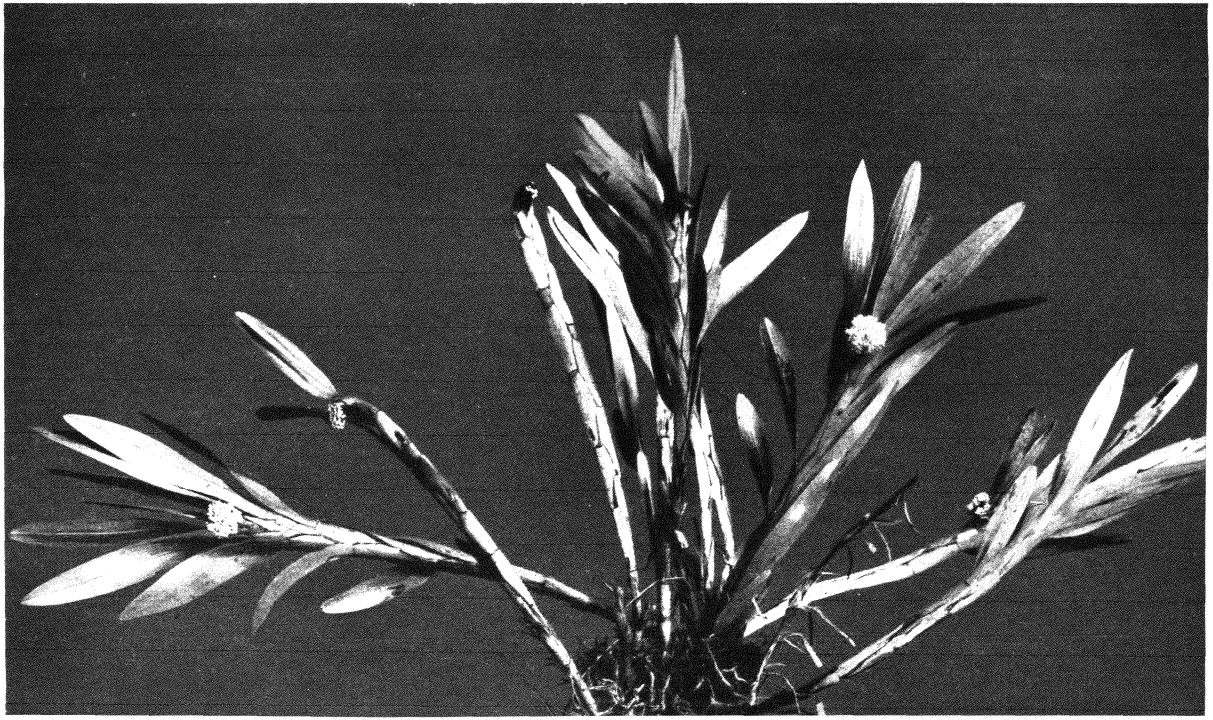

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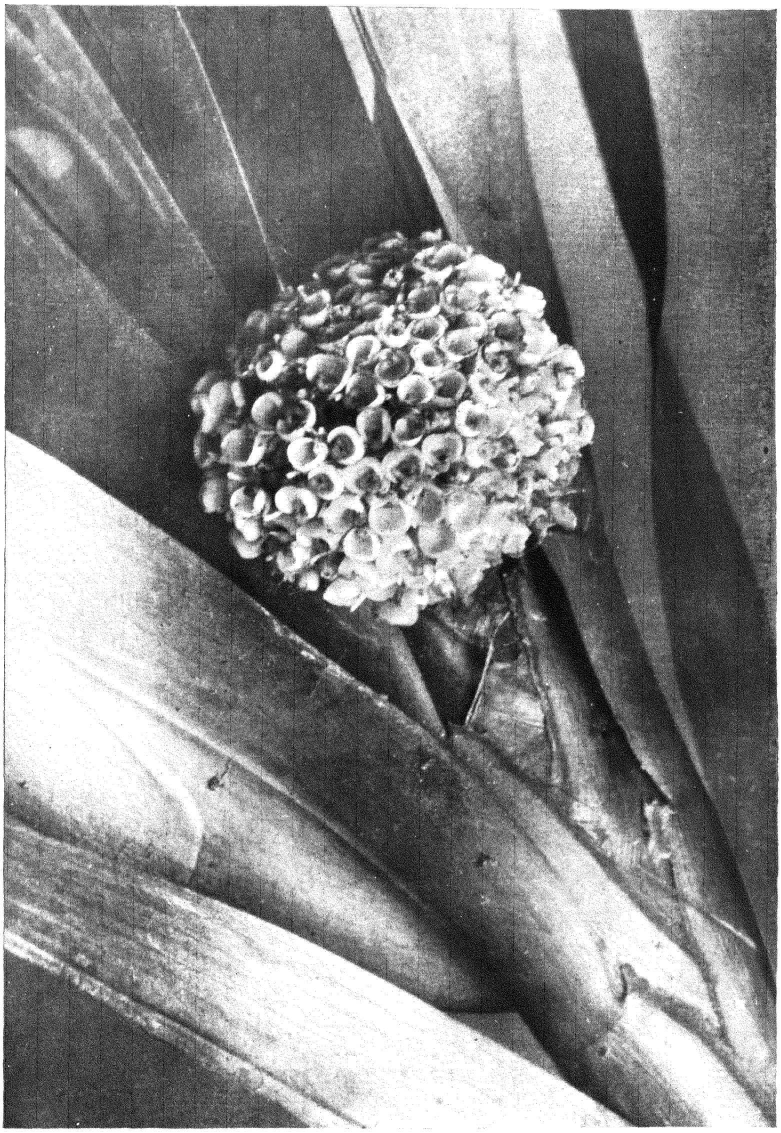

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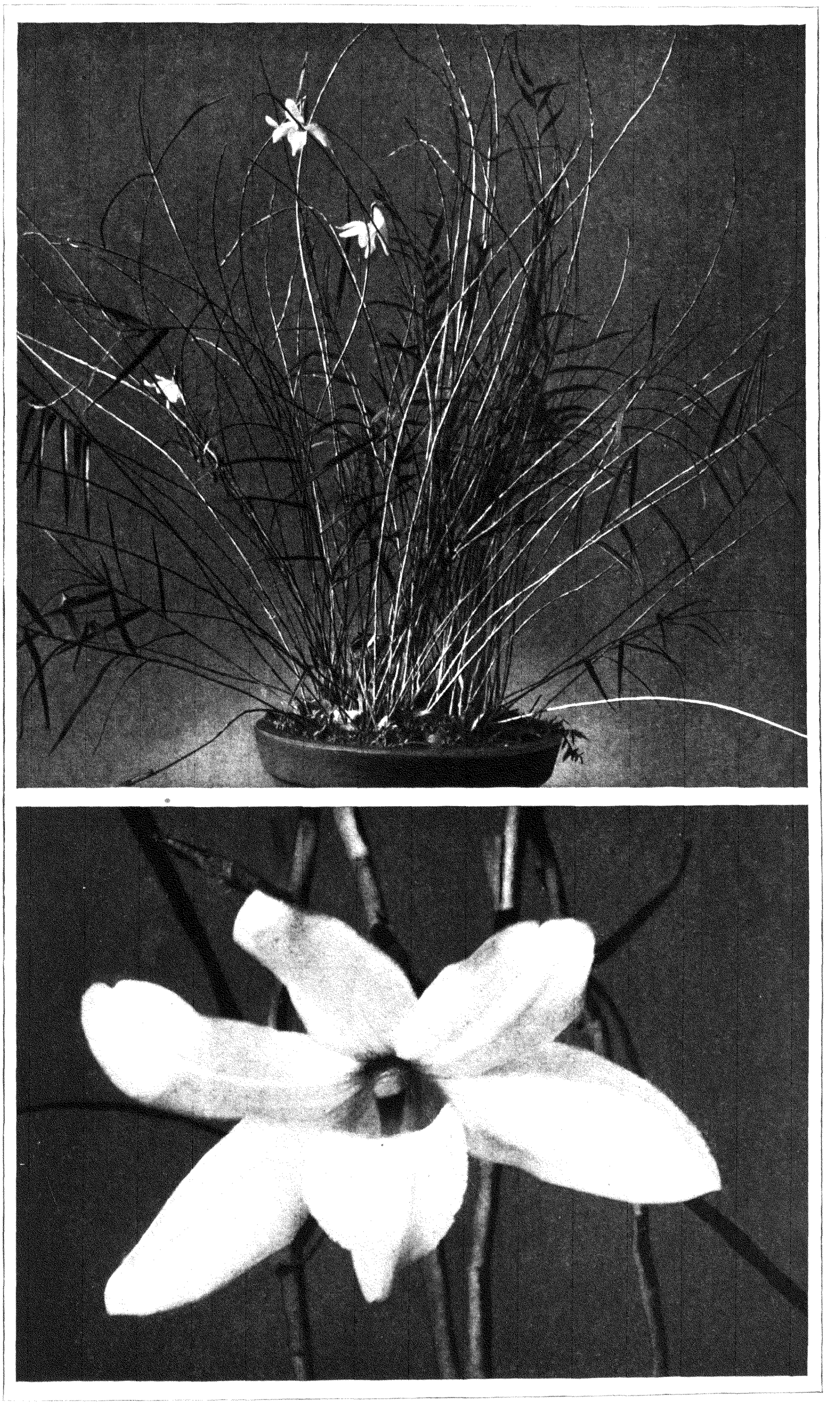

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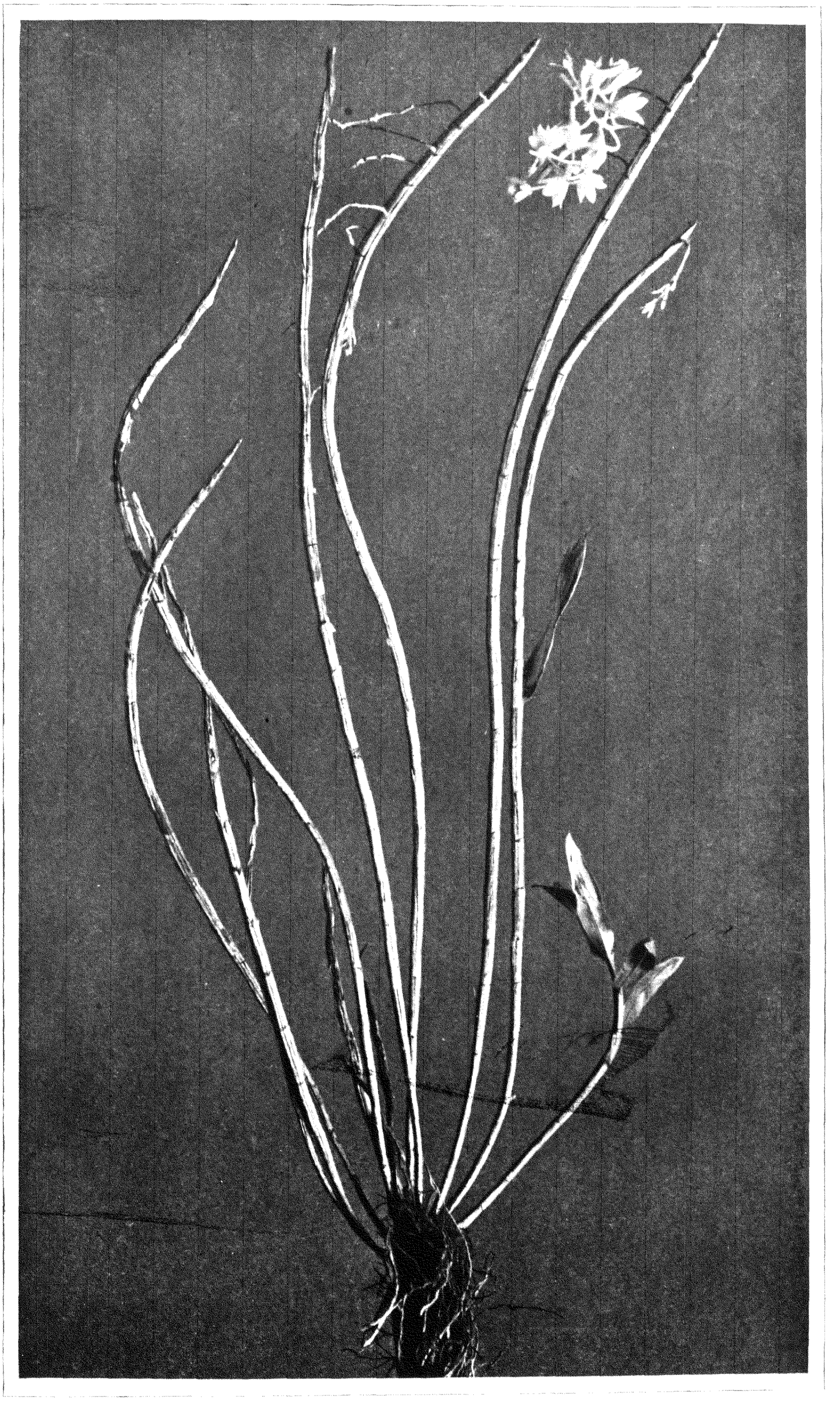

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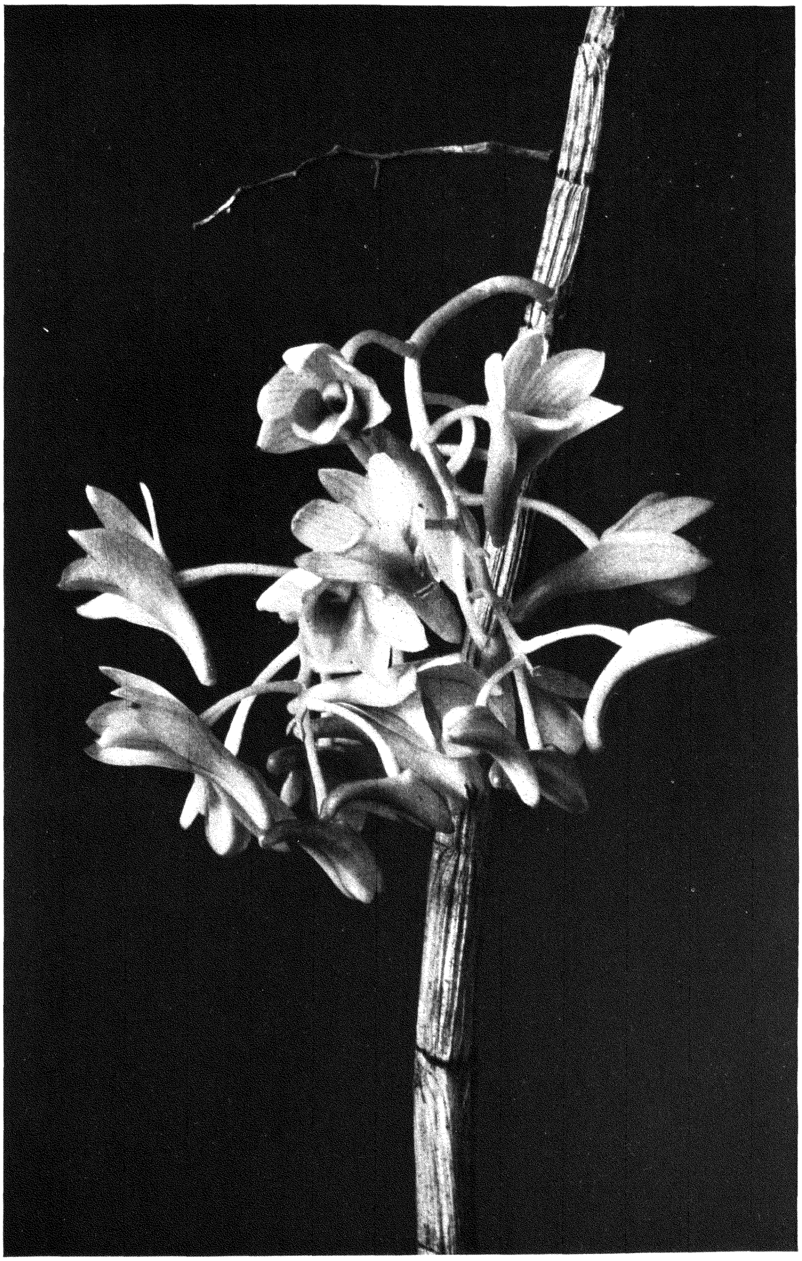

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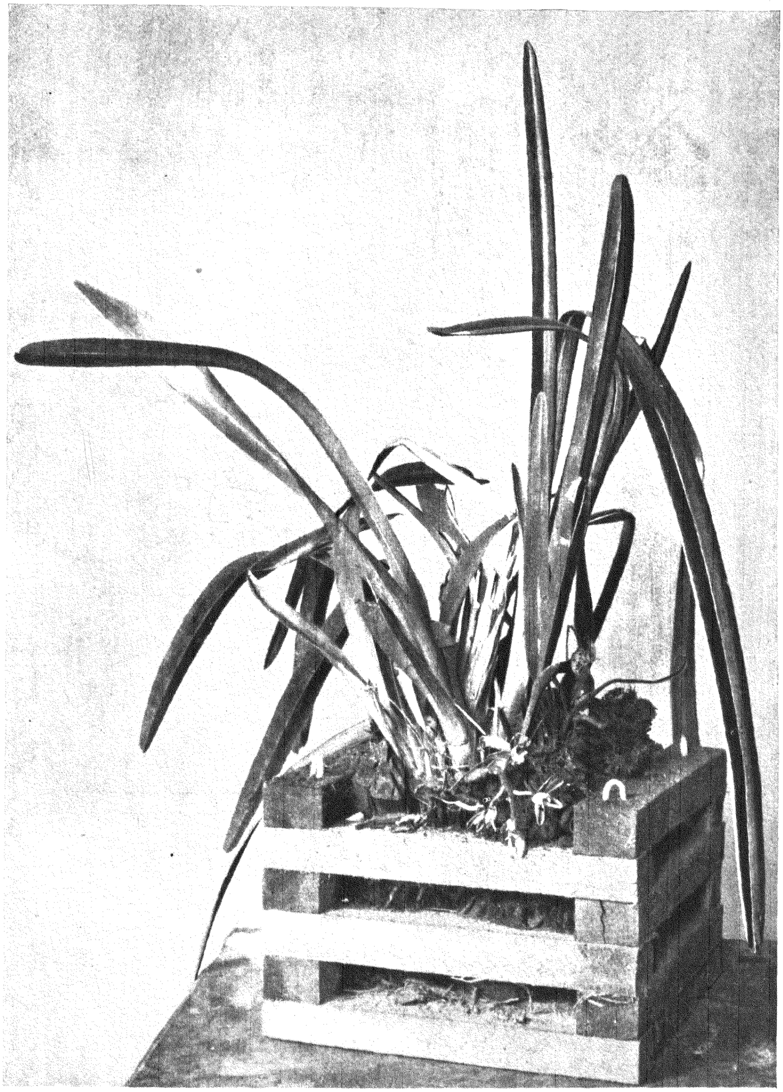

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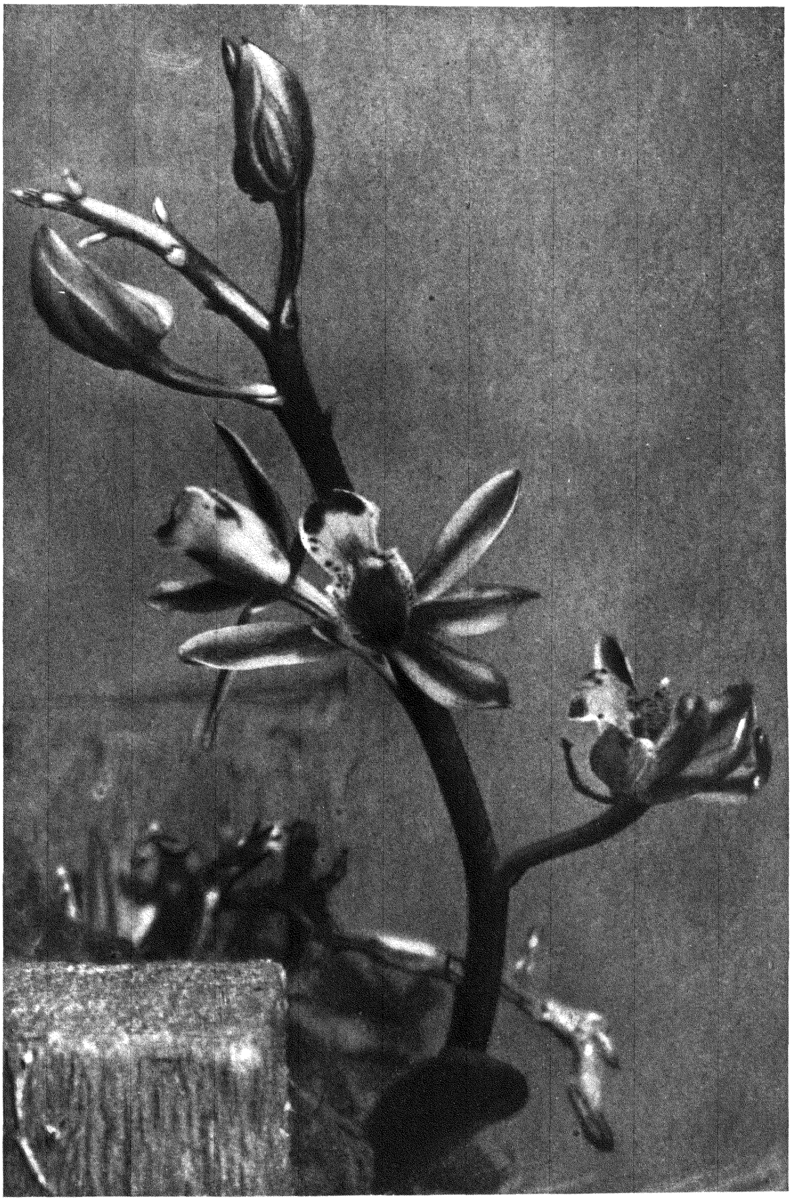

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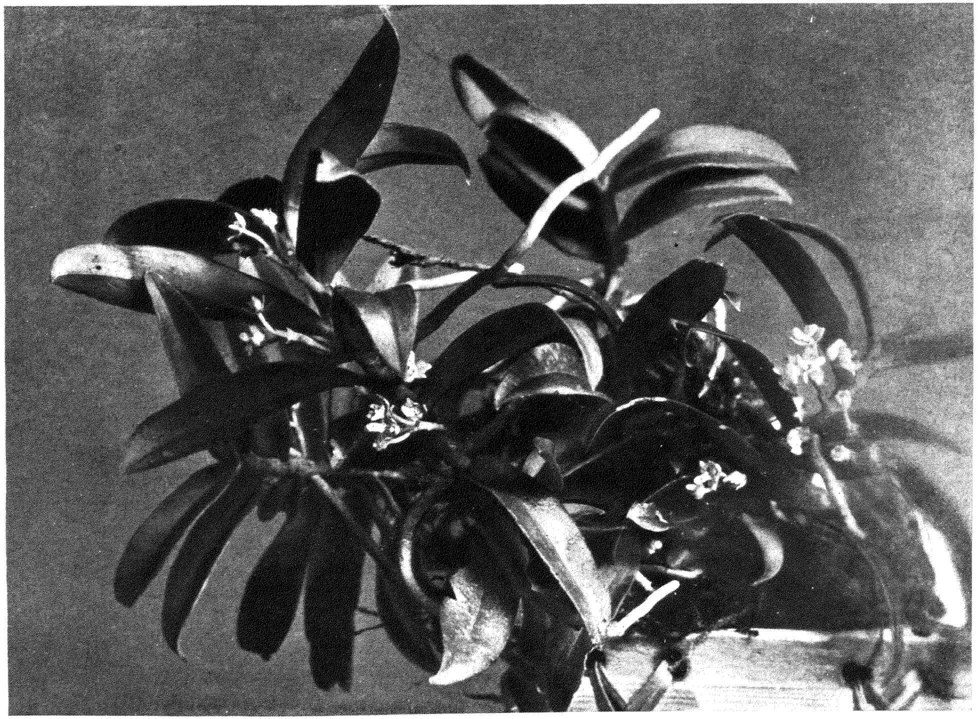

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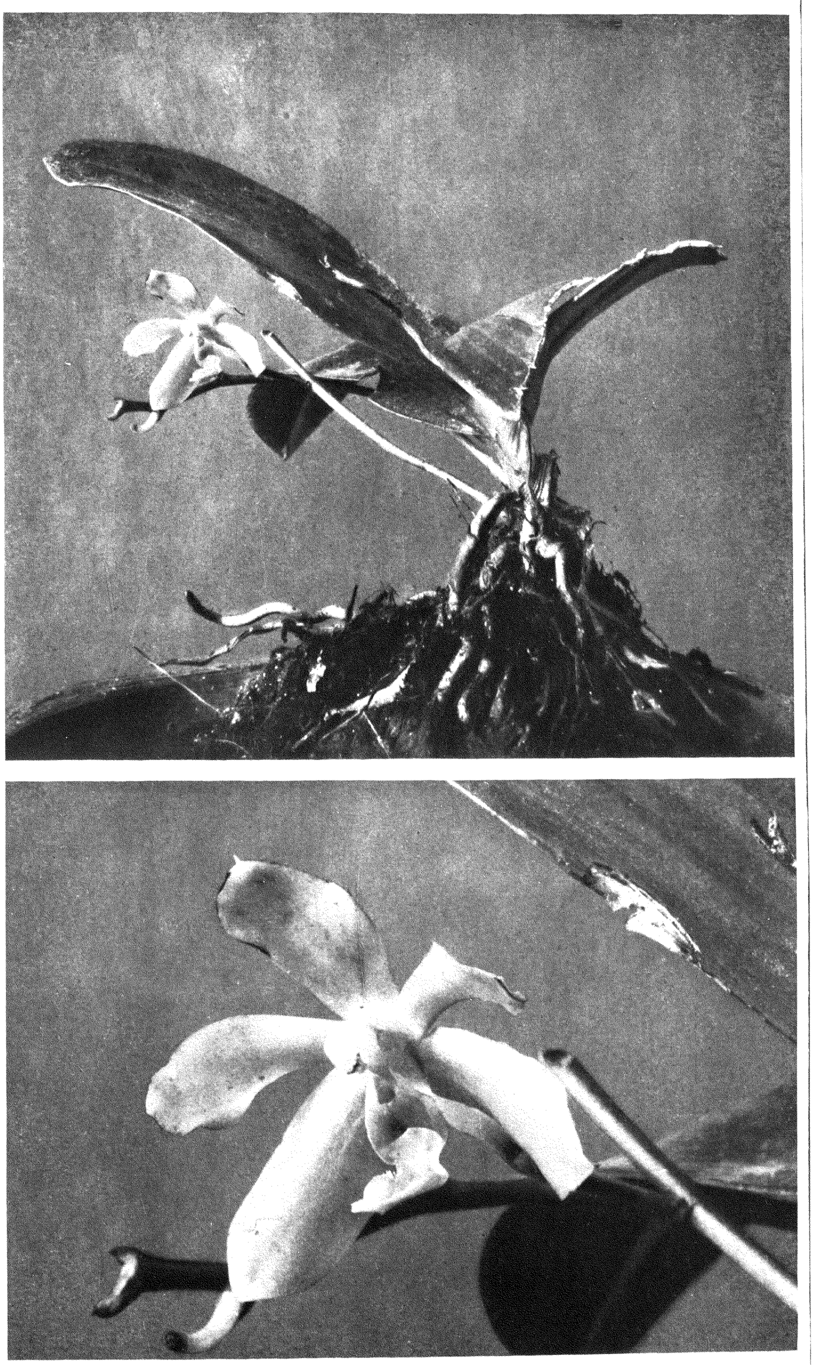

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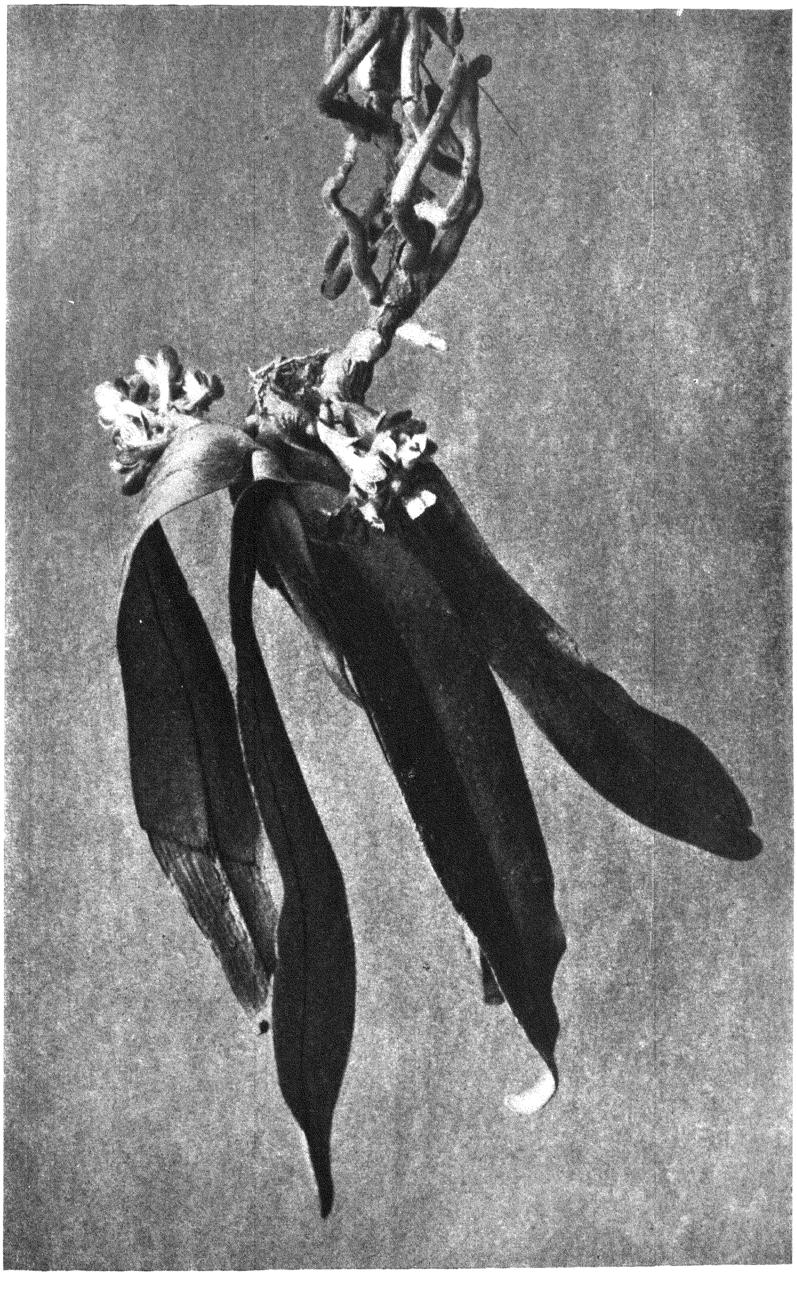

PLATE 25.

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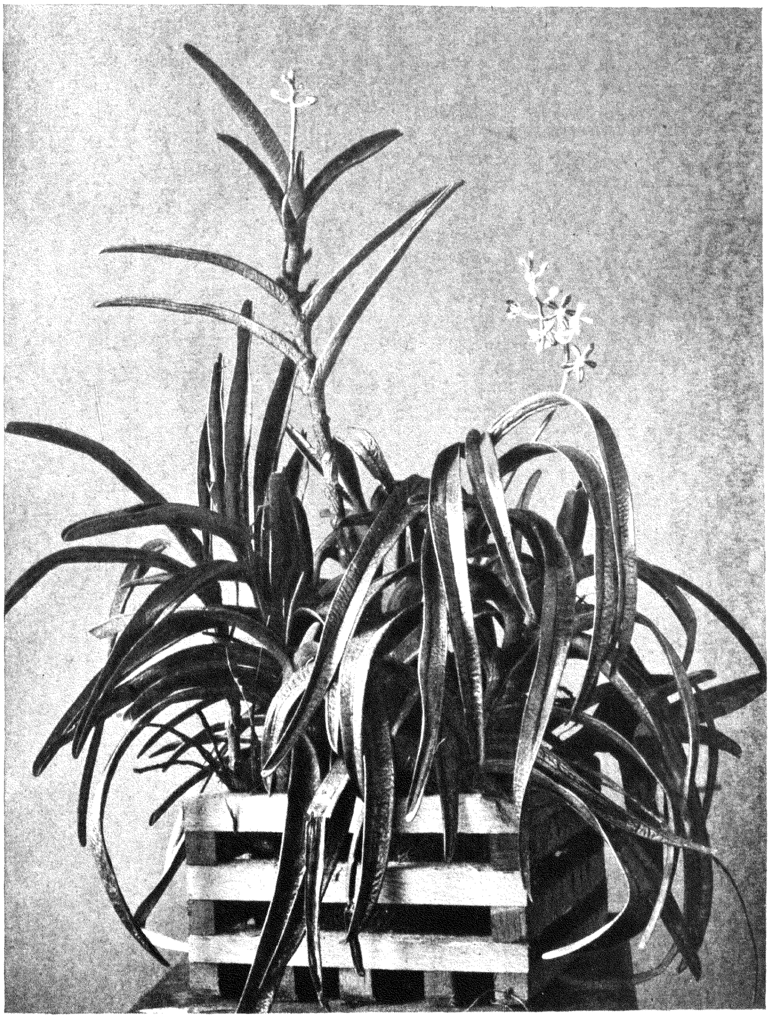

PLATE 26.

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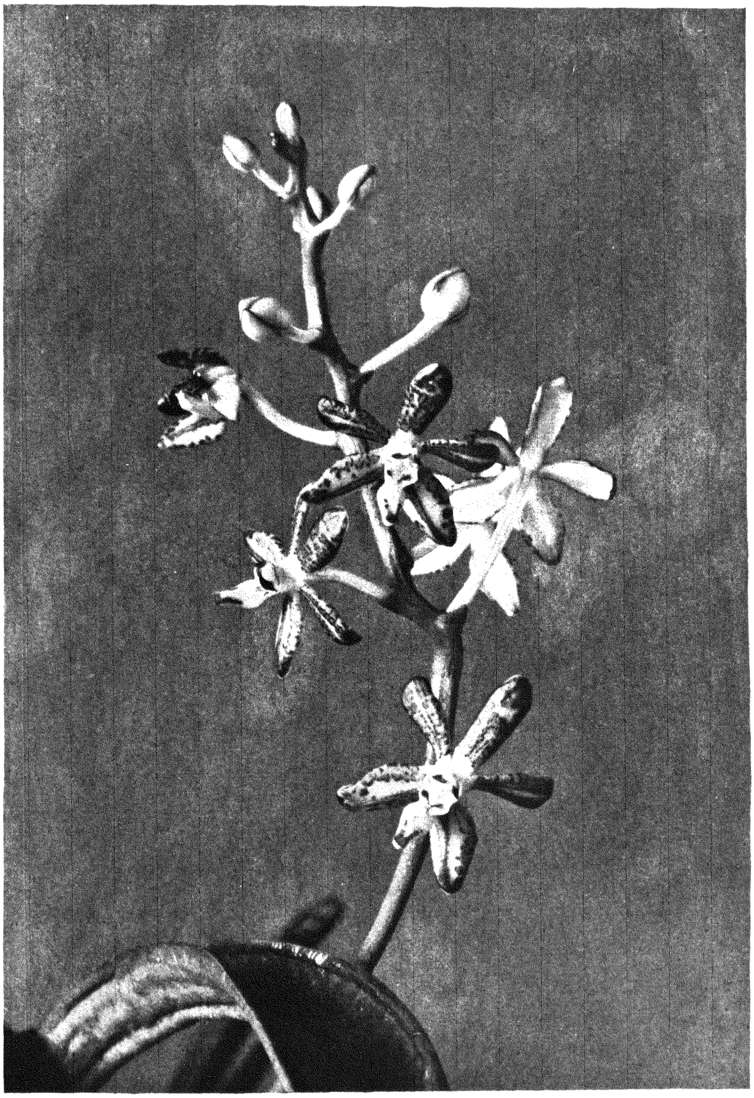

PLATE 27.

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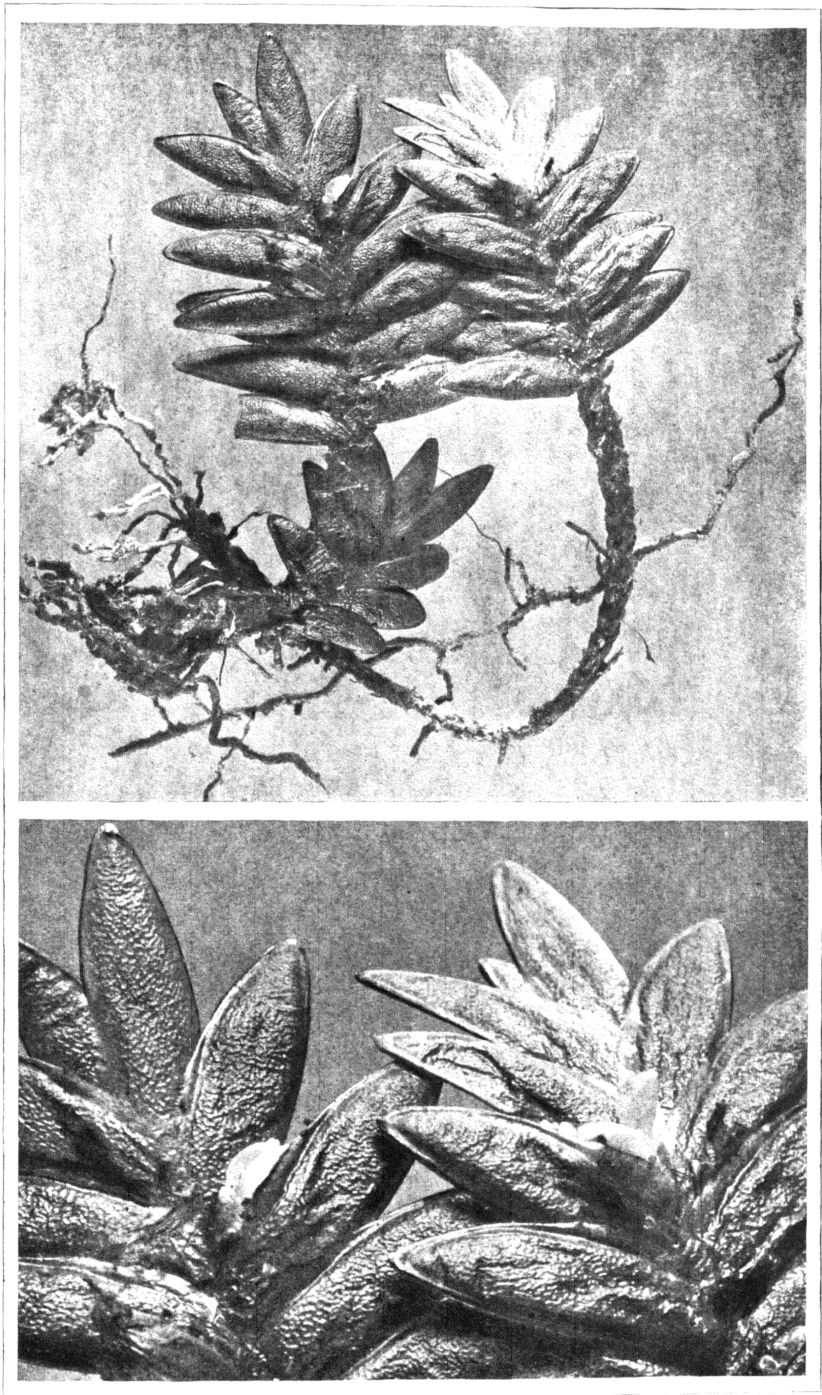

PLATE 28.

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ANOTHER COLLECTION OF FRESH-WATER SPONGES FROM THE PHILIPPINE ISLANDS

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NINE TEXT FIGURES

INTRODUCTION

The writer's summary of our knowledge of the fresh-water sponges of the Philippine Islands was published in September, 1931,[1] and listed the four species described up to that time. Through the interest of R. C. McGregor, a collection of sponges made from Pasig River, between Pasig and Laguna de Bay, by Francisco S. Rivera in October, 1930, was sent me for study and a paper describing four additional species, three of them new, was published.[2] Since the preparation of that paper, another species, *Dosilia plumosa,* has been discovered in that collection.

This third report is based upon another interesting collection of sponges, made from the following localities by Messrs. Duyag and Rivera, under the direction of Mr. McGregor:

1. Collections made by Francisco S. Rivera January 6, 1932, and by A. C. Duyag January 12, 1932, at Pinagbuhatan, Rizal, Luzon.
2. A collection made by A. C. Duyag January 11, 1932, at Novaliches, Rizal, Luzon.
3. A collection made by A. C. Duyag January 19, 1932, at San Jose del Monte, Bulacan, Luzon.
4. A collection made by A. C. Duyag January 21, 1932, at Lamesa Dam, Novaliches, Rizal, Luzon.

The collections from Pinagbuhatan contained the following eight sponges:

Spongilla carteri.
Spongilla fragilis var. *decipiens.*
Spongilla proliferens.

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[1] Philip. Journ. Sci. 46 (1931) 61–75.

[2] Philip. Journ. Sci. 48 (August, 1932).

Ephydatia crateriformis.
Ephydatia fortis var. *vorstmani.*
Trochospongilla latouchiana.
Trochospongilla phillottiana var. *tunghuensis.*
Dosilia plumosa.

Spongilla fragilis var. *decipiens* was also collected at Novaliches, San Jose del Monte, and Lamesa Dam. *Ephydatia crateriformis* was also found at Lamesa Dam.

It is through the continued interest of Mr. R. C. McGregor that I am able to make these studies, and it is to be hoped that collections covering a wider range of territory and on other islands of the group may be made.

Mr. McGregor has kindly given me the following additional information concerning the several localities from which collections of sponges have so far been made in the Philippine Islands by Bureau of Science collectors under his direction.

1. Pasig River connects a large lake—Laguna de Bay—with Manila Bay and is practically a sewer for Manila as well as several small towns along its banks. High tide backs the water of the Pasig into the lake and both river and lake are full of dirt and trash. The river water is thick with organic matter. The lake is at a low level and the flow of the river is sluggish.
2. Pinagbuhatan is a small town on the banks of Pasig River.
3. Novaliches is a small town about 20 kilometers north of Manila in Rizal Province. Its elevation above sea level is very slight, possibly about 10 meters. The collections of sponges in this place were made from a small, sluggish, muddy stream right at the town.
4. Lamesa Dam, a few kilometers from Novaliches, was built several years ago to impound water for the use of Manila. A large artificial lake has resulted. The dam is only a few kilometers from Novaliches and has only a slight elevation, 10 to 20 meters, above sea level.
5. San Jose del Monte is a small town in Bulacan Province, about 10 kilometers northwest of Novaliches. It is in a country very similar to that around Novaliches. This whole area is volcanic tuff with thin or no covering soil. The elevation is slight, possibly a little higher than Novaliches. The sponges collected in this locality were taken from a small river with clear water.

The table herewith includes a complete list of the fresh-water sponges known from the Philippine Islands to May 6, 1932.

SPONGILLA PROLIFERENS Annandale, 1907. Fig. 1.

Spongilla cinerea WEBER (nec Carter), 1890.
Spongilla lacustris var. *proliferens* ANNANDALE, 1918.

Historical statement.—This species was originally described and figured by Annandale from specimens collected in the In-

Fresh-water sponges known from the Philippine Islands.

No.	Species.	Year described.	Philippine collection.		Type specimen in—
			Locality.	Year.	
1	*Ephydatia fortis* Weltner.	1895	Libmanan River, Luzon.	----------	Berlin Museum.
2	*Spongilla clementis* Annandale.	1909	Lake Lanao, Mindanao.	1907	United States National Museum.
3	*Spongilla philippinensis* Annandale.	1909	do	1907 and 1908.	Do.
4	*Spongilla microsclerifera* Annandale.	1909	Taal Lake, Taal Island, Luzon.	1907	Do.
5	*Spongilla tinei* Gee	1932	Pasig River, Pasig	1930	Gee's collection.
6	*Spongilla luzonensis* Gee.	1932	do	1930	Do.
7	*Trochospongilla latouchiana* var. *pasigensis* Gee.	1931	do	1930	Do.
8	*Ephydatia fluviatilis* var. *meyeni* (Carter).	1849	do	1930	British Museum.
9	*Spongilla carteri* Carter	1859	Pinagbuhatan, Rizal, Luzon.	1932	Do.
10	*Spongilla fragilis* var. *decipiens* Weber.	1890	Pinagbuhatan, Lamesa Dam, Novaliches, and San Jose del Monte, Luzon.	1932	Amsterdam Museum
11	*Spongilla proliferens* Annandale.	1907	Pinagbuhatan, Rizal, Luzon.	1932	Indian Museum.
12	*Ephydatia crateriformis* Potts.	1882	Pinagbuhatan and Lamesa Dam.	1932	United States National Museum. Cotype only.
13	*Ephydatia fortis* var. *vorstmani* Gee.	1930	Pinagbuhatan, Rizal, Luzon.	1932	Buitenzorg Museum.
14	*Trochospongilla latouchiana* Annandale.	1907	do	1932	Indian Museum.
15	*Trochospongilla phillottiana* var. *tunghuensis* Gee.	1926	do	1932	Gee's collection.
16	*Dosilia plumosa* Carter	1849	Pasig River, Pasig Pinagbuhatan	1930 1932	British Museum.

dian Museum tank in Calcutta, India.[3] At that time Annandale considered this sponge as a distinct species, and in 1911 he again described it as a separate species, but in 1918 [4] he listed it as a variety of that cosmopolitan species *Spongilla lacustris*. The original illustrations accompanying his description seem to me to confirm this position, but specimens in my collection from the Indian Museum indicated as this species raise serious doubts in one's mind as to the accuracy of these original drawings. The descriptions are not given in enough detail to enable one to come to a final decision in the matter. Schröder maintains that the forked or branched spines of the gemmule spicule is the chief distinguishing characteristic of this species; this position, however, does not seem to me altogether satisfactory though it was accepted tentatively in my description of this species from Java.[5] A sponge similar to that one has been found in the Philippine collections made from Pinagbuhatan, January 6, 1932. This sponge is quite different from *Spongilla lacustris* and is undoubtedly entitled to specific distinction.

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[3] Journ. and Proc. Asiatic Soc. Bengal 3 (1907) 15–17.

[4] Mem. Asiatic Soc. Bengal 6 (1918) 210.

Habitat.—In India, this species was found in permanent ponds; in Malaysia, Weber found it in small streams. There are only a few small specimens in the materials sent from Pinagbuhatan and they were all growing on small dead sticks,

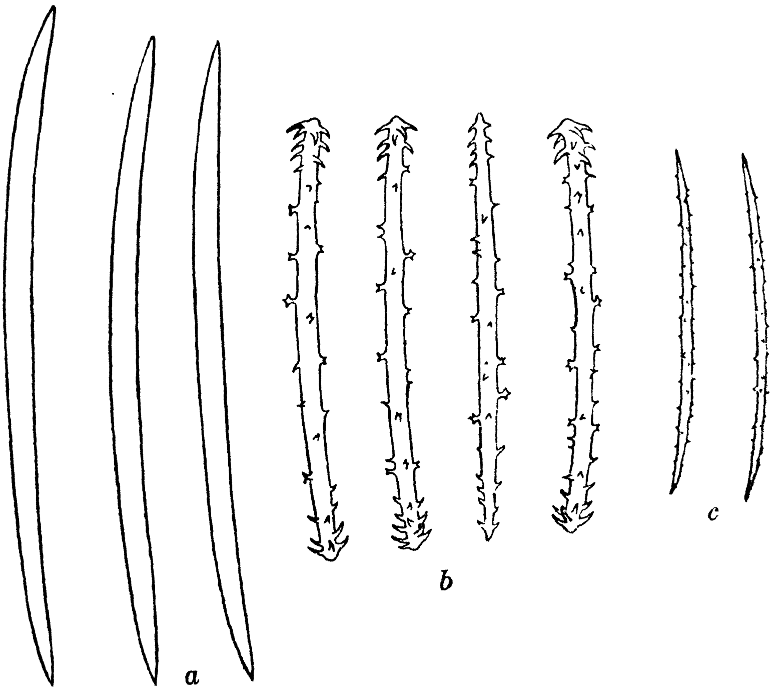

FIG. 1. *Spongilla proliferens*, spicules; *a*, smooth skeleton spicules; *b*, gemmule spicules, showing heavy, recurved spines near the ends and the divided or multiple-pointed spines in the middle area of the spicules; *c*, the small sharp-pointed flesh spicules.

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[5] Treubia 12 (1930) 77–81.

entirely covering their supports with a very thin layer of sponge; the thickness of the sponge does not in any case exceed 3 or 4 millimeters and the longest specimen covers the support for a length of 7 centimeters.

General characteristics.—None of these Philippine sponges representing this species have any outstanding body form by which they may be identified; they are all small and their shape is entirely determined by the supports upon which they were growing. The surfaces of the sponges are irregular, but have been rather badly broken in transmission; they do not appear to have borne lobes or branches; neither do their surfaces closely resemble the larger Java sponges of this species. The oscula are few and inconspicuous. The entire sponge is easily broken. In one or two of the specimens gemmules are lacking but in others they are abundant. These sponges have evidently been growing close to the colonies of *Spongilla carteri* and there is more or less mixing of the gemmules of that common species with those of the rarer *Spongilla proliferens.*

Color.—All of the specimens of this sponge are green in color, due to the presence of a symbiotic algal form growing with them.

Structure.—The skeletal structure is made up of irregular meshes with no conspicuous long spicula fibers. The fibers are all thin and composed of a small number of spicules; this causes the meshes to be rather loose and fragile, and they crumble very easily. The amount of spongin is not large, though often thin films of it may spread over the space between the sides of the meshes.

Skeleton spicules.—The skeleton spicules are spindle shaped, and in most cases are tapering gradually from the center to very sharp points at their ends. They are smooth, slightly curved, rarely straight, rather long and thin. They measure from 331 to 416 microns long and average from 12 to 14 microns in diameter; some of them are slightly smaller but a few may measure as much as 18 microns in thickness.

Flesh spicules.—The flesh spicules are very rare in these specimens. They are thicker at the center and become smaller toward their ends; the ends usually terminate in sharp points. They are gently curved and bear very minute, sharp, conical spines scattered sparsely all over their surface right up to near their ends. In their thickest part they are less than half as thick as the gemmule spicules. They vary in length from around 78 to 90 microns and from 1.5 to 3 microns in thickness in their centers.

Gemmules.—The gemmules are spherical, abundant in some of the specimens, and are light brown or dirty white in color, thus contrasting sharply with the general green color of the sponge. They occur singly and are scattered indiscriminately throughout the sponge body. They have a simple pore tube which at times projects somewhat beyond the surface of the gemmule coat and is surrounded by gemmule spicules bound together by the granular material with which the prevailingly perpendicularly arranged gemmule spicules are held together. Many of the gemmules do not seem to have projecting pore tubes or they are broken off in the teasing of them out of the sponge. The spicules on the outer portion of the gemmule are often irregularly arranged and have no definite system at all; the inner ones are quite regular and are perpendicular to the surface of the gemmule. The Philippine representatives of this species have gemmules measuring from 493 to 562 microns in diameter.

Gemmule spicules.—The gemmule spicules are curved, rarely straight, cylindrical ones of an almost uniform diameter terminating either in rounded ends with a number of sharp, recurved spines around them, or in a large sharp spine around the base of which are arranged similar recurved spines; even the terminal spine itself is often curved. The sharp-pointed, recurved spines extend a short distance from each end toward the center of the spicule but are then replaced by divided or compound spines; they may form simple or modified Y-shaped spines, or they may frequently form compound ones such as this; these spines may have a great variety of forms, from simple conical ones to several branched ones. While the spines are all over the spicule, yet they are often more numerous nearer the ends and are fewer and more scattered in the central region. The spicules vary in length from 88 to 96 microns and are from 3 to 5 or 6 microns thick.

Type.—Annandale's type of this species is preserved in the collections of the Indian Museum, Calcutta, India.

Distribution.—*Spongilla proliferens* is now known from all over eastern India, from Cochin on the western coast of India, from Ceylon, from several localities in Burma, from Java, from Flores, from Celebes, and from Lombok. This record from the Philippine Islands extends its range considerably. There are two forms of a very similar sponge found in several places in eastern China along the coastal provinces and also in Japan; Annandale called these *Spongilla micron* and *S. semispongilla.* Doubt still attaches to the correctness of these identifications.

Remarks.—There seems to be a good deal of confusion and uncertainty with reference to this sponge. Annandale (1911) states that "*Spongilla proliferens* can be distinguished from all forms of *Spongilla lacustris* and *Spongilla alba* by the fact that its gemmules possess a foraminal tubule; from *Spongilla cinerea,* it can be distinguished by its color and its smooth skeleton spicules; from *Spongilla travancorica* by its free gemmules."

In 1909 Annandale described *Spongilla semispongilla* from Japan and he distinguished this from *Spongilla lacustris* by the "peculiarities of its gemmule spicules and by the complete absence of microscleres" (flesh spicules). In 1916, Annandale described *Spongilla micron* from China and he distinguished this from *S. alba* by its invariably smaller size, by the subrotulate form of its gemmule spicules, and by the absence of true flesh spicules. He distinguished *S. micron* from *S. semispongilla* by the entire absence of chlorophyll bodies and the much more slender skeleton spicules of the former.

It seems to the writer that there is little danger of confusing *Spongilla proliferens* with *S. lacustris, S. alba,* or *S. travancorica* (now a synonym of *S. alba*), but there is a great deal of similarity between *S. proliferens, S. micron,* and *S. semispongilla.* If we accept the gemmule spicule as the final criterion, then these three sponges probably belong to the same species and the last two would become synonyms, or varieties at most, of *S. proliferens.*

The questions of the presence of flesh spicules and of the projecting pore tube of the gemmule are open to doubt. It is very easy to confuse the very young gemmule spicules with flesh spicules when the sponges are found in the actively growing stage, especially when the flesh spicules are very rare, as they are in *Spongilla proliferens.* I find in my cotypes of both *S. micron* and *S. semispongilla* very young gemmule spicules which might readily be taken for flesh spicules.

When gemmules are carefully teased out with their adherent spicules from the sponge body, often there are small bunches of spicules and granular material built up around the pore tube, but even in *S. proliferens* many of the gemmules are without the projecting tubes.

Further study must be made of this subject before one is prepared to accept unreservedly the idea that these three sponges, *S. proliferens, S. micron,* and *S. semispongilla,* are identical; we readily accept the idea that they are closely related.

SPONGILLA CARTERI Carter, 1859 (Bowerbank in literature). Fig. 2.

Spongilla friabilis CARTER, 1849 (nec Lamarck).

Historical statement.—Since there seems to be an element of doubt about this sponge being the one described by Carter,[6] it would seem the wiser course to accept his description of this sponge in this same publication,[7] as the type description. Carter sent his specimen to Bowerbank, who after examination gave it the name *Spongilla carteri.* Bowerbank's description [8] did not appear in print, however, until several years after Carter's article mentioned above had been printed in 1859. This makes it necessary to credit the species to Carter (because he made public the first description of it) though the species was named for him by Bowerbank. Since Bowerbank's description this species has been described and illustrated a number of times. The writer has recently published a full illustrated description.[9]

Habitat.—In other parts of the world this sponge has been found growing both in running and in still waters. The China specimens have come almost exclusively from still water, in fact largely from the shallow ponds among the paddy fields. Some of the specimens were growing upon a basal support, but most of them are around plant supports or are thoroughly impregnated with clay. Several of the Java specimens are very clean and free from sediment. The Philippine Islands sponges of this species were all collected at Pinagbuhatan and are, as a rule, much cleaner and much freer from sediment than are the China ones; some of the Philippine Islands specimens, however, are also full of sediment.

General characteristics.—The collection contains many of these sponges and it is judged that they were very abundant. They vary in size from more or less elongated or oval colonies from 3 or 4 centimeters in length and 2 or 3 centimeters in diameter to very much larger colonies, measuring as much as 18 centi-

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[6] Ann. & Mag. Nat. Hist. II 4 (1849) 83.

[7] Ann. & Mag. Nat. Hist. III 3 (1859) 334.

[8] Proc. Zool. Soc. London (1863) 469.

[9] Treubia 12 (1930) 70–74.

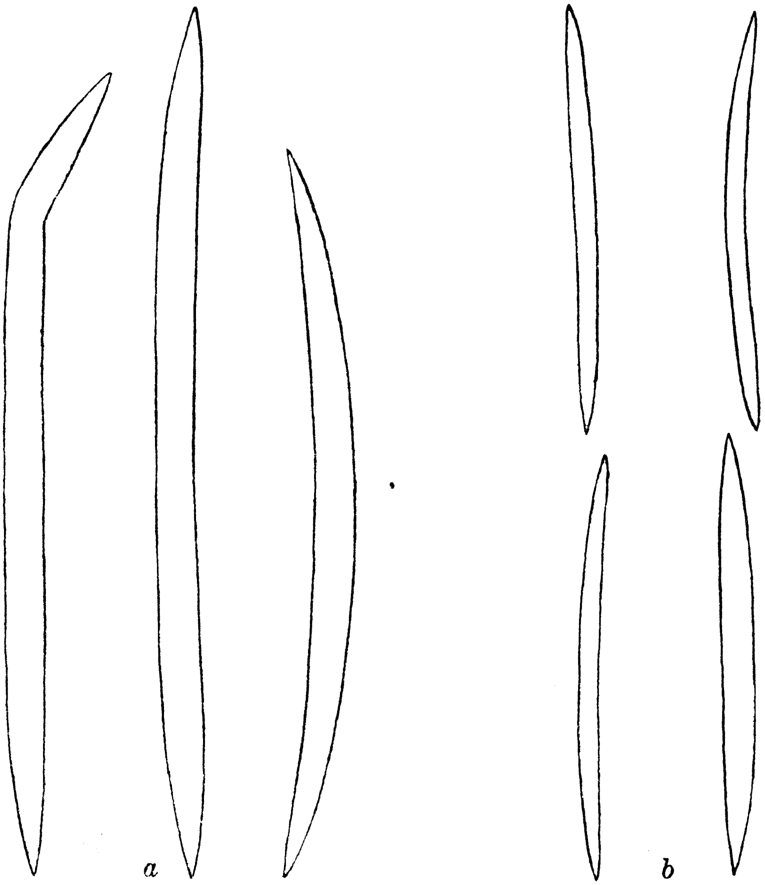

FIG 2. *Spongilla carteri*, spicules; *a*, smooth skeleton spicules; *b*, very similar, but smaller, gemmule spicules.

meters long by 8 or 10 centimeters in diameter. The surfaces are rarely smooth, generally they are very irregular with numerous elevations and depressions, sometimes with short, rounded knobs or lobes projecting from the surface. All of the specimens are full of gemmules massed in the meshes throughout the parenchyma. In nearly every sponge there is at least one large osculum, sometimes more than one. In some of my specimens the oscula have diameters as large as 1 centimeter or over.

Color.—Nearly all of the sponges are a dirty light brown on the inside; the cleaner the sponge the lighter the color will be. In some cases the sponges are covered with a green algal growth, while other sponges are almost black.

Structure.—Definite vertical fibers begin from the support on which the sponge is growing and extend all the way to its outer surface. The fibers are composed of several of the heavy spicules and are bound together by thinner and shorter irregular transverse fibers. The amount of spongin is not large and the sponges crumble very readily from rough handling. The structure of the body is open and when dry the gemmules in large numbers are easily shaken out when the sponges are being examined.

Skeleton spicules.—The skeleton spicules are rather heavy, spindle-shaped, thicker in the center and gradually taper to pointed ends. They are smooth and generally a little curved, though straight spicules are not entirely lacking. Considerable variations in the spicule dimensions occur; they vary in length from 289 to 365 microns and in diameter from 14 to 24 microns.

Flesh spicules.—*Spongilla carteri* does not have any flesh spicules.

Gemmules.—The gemmules occur singly and are very abundant, being scattered without any definite arrangement throughout the entire sponge body from the support on which it grows right on up to near the outer surface. Each spherical gemmule is surrounded by a thick layer of regularly arranged polygonal air cells, within and on the surface of which the gemmule spicules are placed. When observed from the side, the air-cell walls seem to form a series of nearly parallel lines perpendicular to the surface of the gemmules and these lines are connected by short transverse lines, or cell walls, at fairly regular intervals. The pore tube is simple and is sometimes slightly constricted as it emerges from the gemmule, but it expands and opens into a funnel-like depression on the outer surface of the gemmule air-cell coat. The gemmules are slightly lighter in color than the sponge parenchyma and are quite large, measuring from 450 to 600 microns in diameter.

Gemmule spicules.—The gemmule spicules are very similar to those of the skeleton, they are smaller, more curved, smooth, and sharp pointed. Often one or both ends may be decidedly curved inward, forming a bowlike structure; sometimes abnormally shaped spicules are fairly numerous in the slides. They commonly range between 168 and 206 microns in length and between 5 and 9 microns in thickness.

Type.—The type, the specimen sent by Carter to Bowerbank, is preserved in the collections of the British Museum in London, England.

Distribution.—A form of this sponge, which has been designated as variety *balatonensis,* has been found as far west as Lake Balaton, Hungary. *Spongilla carteri,* or its related forms, has also been found in the following localities from that point eastward: Southern Russia, Persia, Turkestan, India, Ceylon, Burma, Siam, Sumatra, Java, Madura, Flores, and southeastern China, and now it is recorded from Pinagbuhatan, Luzon, Philippine Islands. A specimen from Lake Victoria Nyanza has also been referred to this species, and another specimen has been reported from Mauritius Island, east of Madagascar.

Remarks.—The Philippine specimens of *Spongilla carteri* resemble very closely the specimens I have of this species from China and from Siam. The Java sponges were, on the whole, cleaner and freer from the discoloring sediments and were therefore of a more normal sponge color, that is light yellowish brown. The Java specimens were also more delicate and more fragile and had been, in most cases, badly crushed in transportation. The Philippine specimens were more compact and of a stronger structure and have arrived in better condition.

SPONGILLA FRAGILIS var. DECIPIENS Weber, 1890.[10] Fig. 3.

Spongilla decipiens WEBER, 1890.

Historical statement.—This sponge was first described by Max Weber,[11] of Amsterdam, Holland. It is closely related to the cosmopolitan species, *Spongilla fragilis,* and there was some doubt in Annandale's mind as to whether or not it is entitled to varietal distinction; in 1909, after examining a large series of materials, he placed this sponge as a synonym of *Spongilla fragilis,*[12] stating that the large series of specimens now in the Indian Museum seems to afford a complete transition between *Spongilla fragilis* and Weber's *Spongilla decipiens,* which must, therefore, be regarded as a synonym. In 1911, Annandale[13] calls this sponge a "subspecies" of *Spongilla fragilis,* but in 1918,[14] he records it as a "variety" of that species. It is at least entitled, the writer thinks, to varietal separation.

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[10] Gee, Treubia 12 (1930) 74–77.

[11] Zoologische Ergebnisse einer reise in Niederlandisch Ost-Indien (1890) 40–42.

[12] Proc. U. S. Nat. Mus. 37 (1909) 402.

[13] Fauna British India, Freshwater Sponges, Hydroids, & Polyzoa (1911) 97.

Habitat.—Weber's specimens were collected from Lapadi River, southern Celebes, and were growing on stones, leaves, and branches of trees immersed in strong currents of water. The Philippine Islands specimens were collected in large numbers, indicating their abundance, and from all four of the localities (Pinagbuhatan, Novaliches, Lamesa Dam, and San Jose del Monte) where collections were made; this being the only sponge found in all of the places visited by the collectors in making the present collection. In every case, the sponges were growing on the small submerged stems or roots of plants.

General characteristics.—The specimens of this sponge present three fairly distinct and different methods of growth in the materials which I have in hand, in fact, they were so unlike in appearance that upon a casual examination of the specimens as they were being unpacked, I thought they represented three different sponges. One specimen representing each type of growth will be briefly described.

Growth type 1; specimen 54959.—This specimen is typical of one form. It consists of two sticks, one 15 centimeters long and about 8 millimeters in diameter and a smaller one 10 centimeters long and about 6 millimeters in diameter, both being entirely covered and bound together by a thin film of sponge not more than 3 or 4 millimeters thick in any part and only about 1 to 2 millimeters thick over most of the area. The surface is comparatively even and smooth but is clearly marked in parts by the canals just on the surface seeming to radiate from centers. The color of this specimen is blackish, probably due to the nature of the water in which it was growing. The gemmule peculiarities are described below.

Growth type 2; specimen 54967.—This specimen consists of a small twig, probably a rootlet, the entire length being not more than 10 centimeters. (The greater part of the very large number of specimens representing this type of growth are much larger than the one described; they frequently measure two or three times as long as this one and consist of many branches which bear patches of sponges varying in size and extent. Most of these do not bear gemmules.) In parts of the specimen the sponge joins two or more of the twigs together forming a thin

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[14] Mem. Asiatic Soc. Bengal 6 (1918) 212.

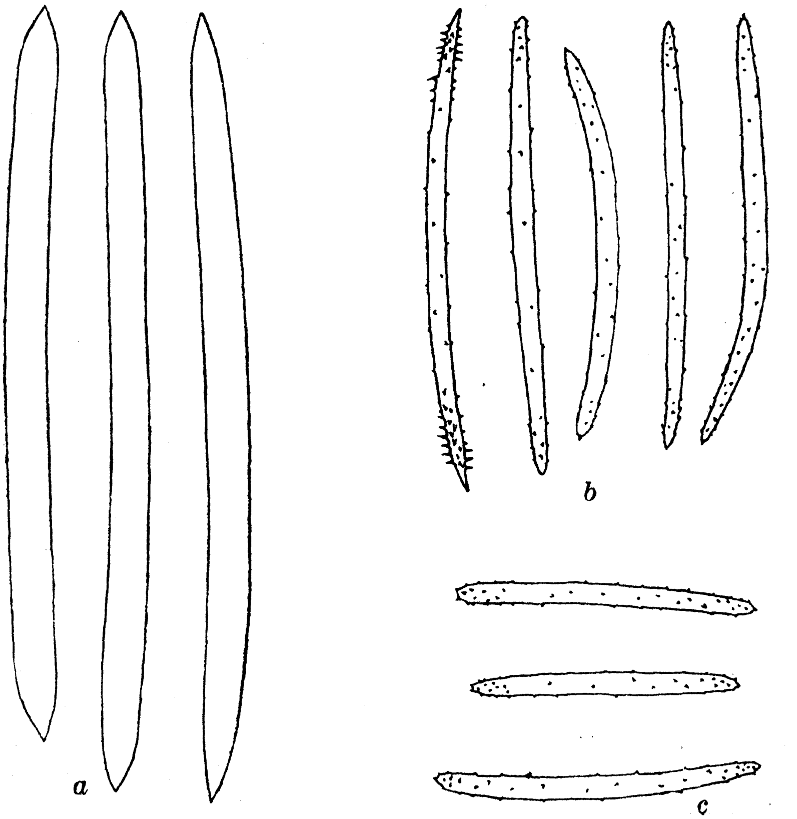

FIG. 3. *Spongilla fragilis* var. *decipiens*, spicules; *a*, smooth skeleton spicules abruptly sharpened; *b*, longer gemmule spicules, showing various shapes and the variety in the size and arrangement of the spines; *c*, shorter gemmule spicules.

layer of sponge across the space between the supports. A portion of the sponge forms a continuous covering of the support, in other parts there are only small nodules which grew around the support; these are thickest in the center and become thinner toward their outer edges. The general form is that of the support, and the smooth, surfaced cushion of sponge is not often more than a few millimeters in thickness. The color of this group of sponges is generally light brown or tan.

Growth type 3; specimen 54941.—This sponge has quite a different habit of growth from the other two and its general appearance would lead one to think that it was not even closely related to them. It also grows on plant supports, altogether covering them but forming larger and thicker masses of sponge. The sponge frequently fuses all the growths around several twigs together into one mass; one specimen is over 15 centimeters long and in certain parts the fused masses of sponge are 4 or 5 centimeters in thickness. The surfaces of this form are also quite irregular, bearing rounded ridges or shallow furrows with rounded bottoms. The color is from a dark brown to black.

Color.—As has been stated above, the color of these sponges varies from a light brown or tan to black; all the intermediate shades may be found by searching through a large series of specimens.

Structure.—The sponge never grows to be very thick in our specimens; the thickest ones are the result of the fusing together of the films around several small twigs. The vertical fibers are weak but distinct and clearly visible; they are bound together by short transversely placed single spicules or small groups which are hardly regular enough to be called fibers. The spongin is small in amount and the fibers are never heavy. The general structure, both in cross section and on the surface, has the appearance of being made up of an uneven meshwork.

Skeleton spicules.—The skeleton spicules are smooth, spindle-shaped, and pointed at both ends. In most cases they are of nearly uniform diameter, tapering only slightly from the center, and are abruptly sharpened into blunted points at the ends. Only a few are straight, most of them being somewhat curved. Now and then much finer spicules are found which taper very gradually into very fine points at their ends. The extremes vary from about 200 to 332 microns in length and from 12 to 22 microns in thickness. The average ones, however, measure from about 230 to 250 microns in length and from 13 to 17 microns in diameter.

Flesh spicules.—There are no flesh spicules in this species.

Gemmules.—The arrangement of the gemmules is different in the three types of growth described above.

Growth type 1.—In this type the gemmules are arranged in a layer at the base of the sponge and upon the support. The layer is generally quite regular and for the most part only one gemmule thick with their pore tubes all pointing upward away from the support. As a rule, these patches are small but one specimen (No. 54945), from which the covering layer of sponge has been removed, is a stick about 1.5 millimeters in diameter and is entirely covered by a solid layer of gemmules for a length of 5 centimeters. In places the layer becomes two gemmules thick and there are several small spots where the layer is even three gemmules thick. This is the largest number of gemmules I have found together in any of the specimens of this species; usually the patches are very much smaller than the one just described. The straight chitinous pore tubes are darker in color than the gemmule coat and they sometimes project beyond the surface of the coat.

Growth type 2.—The patches in this form are generally very small and consist of only a comparatively small number of gemmules forming a single layer at the base of the sponge. One flat patch rather larger than the usual is somewhat elliptical in shape and measures 6 by 3 millimeters. I have not found these in double layers.

Growth type 3.—In the sponges of this type the gemmules are also in a single layer upon the support and some few of them are scattered in the meshes of the sponge. The gemmules in the body of the sponge are usually bound together in small groups and suggest the arrangement typical of *Spongilla fragilis*.

The gemmules are found to be very variable in size, ranging from about 212 to as much as around 500 microns in diameter. They are inclosed in a layer of polygonal air cells. I have found the gemmules in the layer on the support all bound together and the entire layer is of a uniform color. While the upper portion of each gemmule with its pore tube pointing upward rises above this layer yet the lower portion is covered over by this air-cell layer into which are woven and bound tightly together numbers of both skeleton and gemmule spicules. The number of gemmule spicules around the gemmule seems to be very variable; they are placed, as a rule, tangentially and around the base of the pore tubes, their ends often overlap forming a chimneylike structure. I find, contrary to Weber's statement, that the pore tubes do sometimes project a little above the gemmule coat. The lower half of the gemmule seems to have fewer gemmule spicules than the upper portion and frequently even these are left attached to the support as the gemmules are teased away and one might get the idea that the lower half of the gemmule is altogether bare. I have found that the layer of hexagonal, or polygonal, air cells connecting the gemmules all together is present, though I have not found it as clearly defined as Weber has described and illustrated it in his original descriptions.

Gemmule spicules.—The gemmule spicules are usually thicker in the center and gradually taper somewhat to either rounded or sharpened tips. They are generally curved, sometimes irregularly angular, though straight ones, often shorter than the others, are at times found. The spicules bear sharp spines irregularly distributed all over their surfaces; the spines as a rule are larger and more numerous near the ends of the spicules and, in a few cases, one or two large spines have been observed near the end which are curved inward toward the center of the spicule.

These spicules vary from 80 or 90 to 192 microns in length and from 3 or 4 to 11 microns in diameter, but the average ones are from 120 to 150 microns long and from 7 to 9 microns in diameter.

Type.—The type of this sponge is preserved in the Amsterdam Museum, Holland.

Distribution.—The type specimen from which this sponge was originally described by Weber was collected from the Lapadi River at Sare-minja near Pare Pare, on the western coast of South Celebes. Annandale recorded it from the Indian Museum tank, Calcutta, India, on Weltner's authority, but he doubted the identification and believed the specimen in question to be *Spongilla fragilis* var. *calcuttana.* The finding of this sponge in the Philippine Islands extends its range considerably. It was collected in each of the four localities from which specimens in this collection were sent me—Pinagbuhatan, Novaliches, Lamesa Dam, and San Jose del Monte—and, judging from the number of specimens sent, it must be a very common sponge.

Remarks.—Annandale (1911) states that "this (?) local race is distinguished by the fact that the foraminal tubules are invariably short and straight and thickened at the tips, and that gemmule spicules do not occur on the external surface of the cellular coat of the gemmules." In the various specimens examined a few projecting foraminal tubules are found, and most of the gemmules have gemmule spicules on the outer coat of the gemmule. I find that the arrangement of the gemmules, their method of being bound together, and the differences in the spicules of this sponge from those of the type form of the species more constant characters for determining the variety.

EPHYDATIA CRATERIFORMIS (Potts), 1882. Fig. 4.

Meyenia crateriformis POTTS, 1882.
Spongilla crateriformis ANNANDALE, 1911.

Historical statement.—This species was described from specimens collected in Brandywine Creek, near Chadd's Ford in

September, 1881, by E. Potts.[15] This species has been found in other parts of the world, and descriptions of it have appeared a number of times in different journals under both generic names, *Ephydatia* and *Spongilla.* The rotule of the birotulate spicule is distinct, and the writer holds that it properly belongs to the genus *Ephydatia.* This species has now been found in Pinagbuhatan and Lamesa Dam, Novaliches, Philippine Islands. The writer has published a very full discussion of this species.[16]

Habitat.—It seems that this sponge rather prefers still waters and that most of the specimens have been found in ponds, lakes, canals, or other quiet waters. There are many specimens of *Ephydatia crateriformis* in the Philippine Islands collection; and they were without a single exception all growing around or attached to some support, usually small dead twigs many of which must have dropped into the water from overhanging trees. Some of the specimens entirely cover small leaves.

General characteristics.—The very thin cushions of sponges covering the small stems rarely reach a thickness of more than 3 or 4 millimeters, though they may entirely cover their supports more or less evenly for a length of 15 centimeters or more. In a few instances the surfaces of the specimens still bear evidences of a dermal film, which covered them when they were alive in the water, but in most cases this film has been broken away and the exposed areas reveal the fragile, open network of the parenchyma into which are crowded many gemmules.

Color.—There is very great differences in the color of the sponge depending upon the cleanness of the water in which it was growing. Annandale records black sponges in India changing to "pure white" in less than a week when taken from their natural habitat and put into clean, clear water. All of the Philippine specimens of *Ephydatia crateriformis* are either black or very nearly so. The gemmules are white or gray and contrast clearly with the sponge itself.

Structure.—The sponge is made up largely of irregularly shaped meshes into which are crowded a large number of gemmules. These meshes are weak, being composed of a small number of spicules, rarely more than three to five and often only one or two. The amount of spongin is also small and therefore the structure is very fragile. When the sponges are roughly handled or crushed the gemmules are liberated in large numbers and fall out of the parenchyma. In only one or two of the specimens are comparatively large oscula present.

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[15] Proc. Acad. Nae. Sci. (1882) 12–13.

[16] Treubia 12 (1930) 87–92.

Skeleton spicules.—The skeleton spicules are spindle shaped and sharp pointed, but in most cases instead of tapering gradually to a point, they are of almost uniform diameter to near the ends where they become abruptly sharp pointed. A few of them do taper gradually to sharp points. I find none of the spicules with rounded or with spearhead-shaped ends such as are characteristic of some forms of *Ephydatia crateriformis* found in other parts of the world. Generally the spicules are somewhat curved; rare straight ones do occur, however, and they bear a varying number of very fine spines; some of the spicules appear to be smooth and others bear such small spines that they can be seen only under the higher magnifications of the microscope, others bear larger numbers of spines which are clearly visible. The ends of the spicules are always free of spines. As a whole, however, the spicules of the Philippine sponge have as a rule much fewer spines than those of other sponges of this species from elsewhere. The spicules measure from 272 to 323 microns in length and from 12 to 14 microns in thickness.

Flesh spicules.—True flesh spicules are entirely lacking in this species.

Gemmules.—The gemmules are small, white in color, occur singly, and are usually crowded in great abundance throughout the whole body of the sponge. There are, in fact, in some of the specimens so many gemmules that the rather weak skeleton can hardly contain them and, when dry, any rough handling of them shatters out large numbers of the gemmules. They are covered by a coat of granular material in which a single layer of perpendicularly placed gemmule spicules are closely crowded together. Usually the gemmules are spherical, but in some cases they become somewhat elongated, pear-shaped, with the pore tube on the smaller end. The pore tube opens on the surface of the gemmule coat, but in many cases in my specimens the tube appears to have built up around it a mass of granular material with some spicules in this. The gemmules measure from 250 microns in diameter in the smaller ones to as much as 340 microns in the larger ones.

Gemmule spicules.—The gemmule spicules of this Philippine sponge are on the average shorter and more nearly uniform in length than are those from most of the other sponges of this

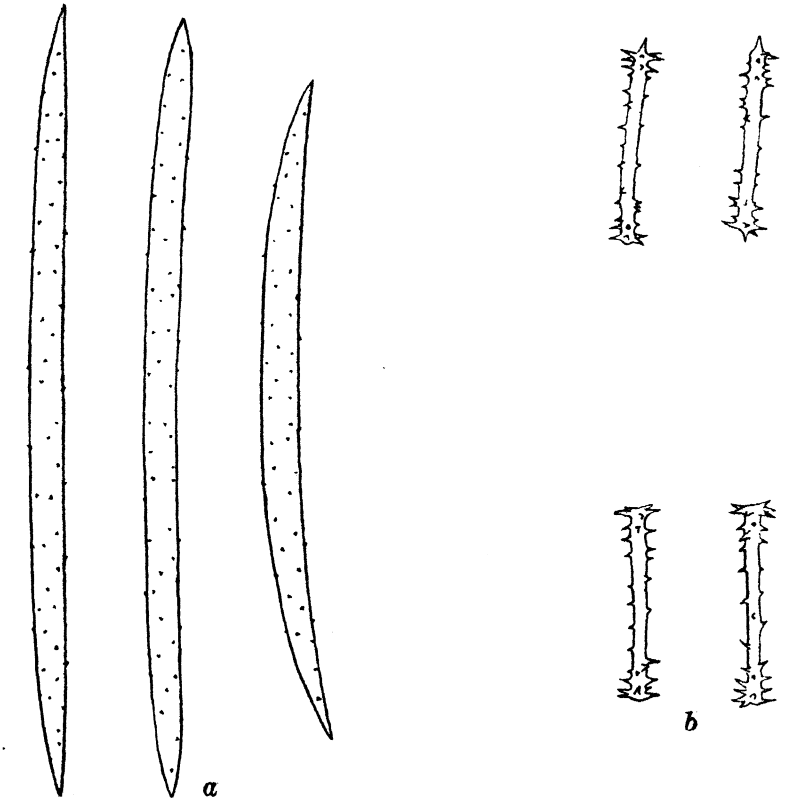

FIG. 4. *Ephydatia crateriformis*, spicules; *a*, spined skeleton spicules; *b*, gemmule spicules; some with sharp ends, others with rounded ends.

species with which I am familiar. They are generally straight, but some are slightly curved. The rotules are as a rule quite well formed by the ring of spines, often slightly recurved, around the ends of the spicules. While the blunt or rounded ends are largely characteristic, yet some of the spicules terminate in a prominent spine. The spines are in the main large, abundant, perpendicular, usually larger and more abundant near the ends of the spicules; some spicules are found, however, on which the spines are more or less evenly distributed over the whole length of the spicule. The spines are more numerous and proportionately heavier in the Philippine sponge than those in the American form of this sponge from the type locality. The spicules measure from 60 to 64 microns long and are from 4 to 5 microns in diameter.

Type.—The type of this species is in the collection of the United States National Museum, Washington, D. C.

Distribution.—*Ephydatia crateriformis* occurs in North America, where it is widely distributed; it has also been found in India, in Burma, on Ross Island, and in southeastern China. It is now recorded for the first time in the Philippine Islands from both Pinagbuhatan and Lamesa Dam, Novaliches, Luzon.

Remarks.—This Philippine sponge resembles some of the China representatives of this species more closely than it does the American ones. It is, however, a very variable sponge and the skeleton spicules in some of the various forms assigned to the species may have their ends rounded; or they may be irregularly shaped resembling spearheads; or they may be nearly cylindrical for most of their length and then abruptly pointed; or they may taper very gradually from the center to very sharp-pointed ends. A decided variableness is also noticeable in the distribution, the size, and the number of spines on the gemmule spicules; some have minute spines or may even be altogether smooth, while others bear prominent spines.

The gemmule spicules of this species are also extremely variable in the size, the number, and the arrangement of the spines on the spicule and in the degree of perfection of the rotule.

It would be difficult in most cases to separate out varieties which are constant enough and distinct enough for recognition. The writer has found and described one such variety, *Ephydatia crateriformis* var. *cantonensis*,[17] where the differences from the type form are both marked and constant.

EPHYDATIA FORTIS var. VORSTMANI Gee, 1930. Fig. 5.

Ephydatia fluviatilis var. *ramsayi* VORSTMAN, 1928.

Historical statement.—Dr. A. G. Vorstman first discovered this sponge and published a brief record of its occurrence in Java.[18] She called it *Ephydatia fluviatilis* var. *ramsayi*. The collection containing some of the specimens was sent to the writer and after a careful study of the sponge it was named as a new variety, *Ephydatia fortis* var. *vorstmani*, and in my paper on the fresh-water sponges of the Dutch East Indies [19] there is a full description of this sponge. There are in the collections from Pinagbuhatan three or four specimens which

[17] Bull. Peking Soc. Nat. Hist. 3 (1928–29) 1–4.

[18] De Tropische Natuur (1928) No. 7.

[19] Treubia 12 (1930) 94–98.

are placed in this variety. Though there are certain differences between the two sponges, yet intergrading forms are found which link the Java and the Philippine sponges together.

Habitat.—The smaller specimens were crushed and are in small pieces but the largest specimen in the Philippine collection is intact and was found growing around the small twigs of a plant; evidently it had grown in clear water for it is quite free from sediment of any kind. Vorstman (1928) stated that her Java specimens were solid in growth, forming round crust-shaped pieces with a diameter of 2 centimeters or more. The Java specimens were found growing exclusively on the surface of stones.

General characteristics.—The sponge was growing around the fine stems of a small portion of a branching plant and had a general, almost symmetrical appearance resembling somewhat the shape of a crab. Its shape was due altogether to the branching support upon which it had grown. The sponge measures about 13 centimeters in its longest part and is about 7 centimeters in its thickest portion. A cross section of a growth around one of the twigs is only about 2.5 centimeters in diameter. One surface of the sponge bears only the minute pores in very large numbers over the entire surface; on the other side are scattered some 18 or 20 conspicuous oscula opening level with the surface and entering into a much-branched system of canals within the sponge. The surface of the sponge is in places covered with green algal growths; these growths seem to be superficial, however, and do not penetrate deeply into the sponge tissue.

The surfaces of the Java sponges had rods and plaits formed by short protuberances which had grown together, giving them a very rough appearance. The Philippine sponges present smoother surfaces with only a few irregularities which are caused largely by the branches of the plant or a very small pyramidal growth now and then on the surface.

Color.—This specimen is a very light tan on the inside tinged with gray on the outer areas; over its surface are scattered a few patches of the green algal growths mentioned above. The gemmules are slightly darker in color than the sponge itself and have something of a yellowish tinge.

Structure.—That portion of the sponge immediately surrounding the small supporting sticks (which are in no case more than 2 or 3 millimeters in diameter) is composed chiefly of irregular meshes into which are crowded large numbers of gemmules. Through this area there are visible a few radiating fibers but these become more regular beyond this inner area and extend in all directions to the surface of the sponge; these radii are quite distinct in the outer portion of the sponge and are composed of several of the heavy spicules bound together by a small amount of spongin; the transverse fibers are less regular but are present at intervals bracing the longer fibers, so that the entire structure is quite firm. The whole of the body of the sponge is penetrated by a well-organized system of canals.

Skeleton spicules.—The skeleton spicules are heavy, straight or only very slightly curved, spindle-shaped ones tapering gradually and becoming more or less abruptly sharp pointed at the ends. One gains the impression at first after an examination with a low-power objective that the spicules are smooth, but closer examination with higher powers reveals very minute spines scattered thinly over the spicule. Now and then spicules are found which bear more numerous and more prominent spines but these are rare. They vary in length from 298 to 382 microns, most of them being around 340 to 350 microns long; in thickness they range from 17 to 24 microns.

Flesh spicules.—Flesh spicules are lacking in this sponge.

Gemmules.—The gemmules occur singly but in fairly large numbers in the inner portion of the sponge; as a general thing they are more abundant right around the support and close to it than they are in the outer part of the sponge. They are a light tan tinged with light yellowish, being only a little darker than the sponge itself. The spherical gemmules, when dry, have one half sunken in forming a bowl-like depression and generally the pore tube opens in the middle of this depression as a simple tube with only a slightly funnel-shaped termination on the surface of the gemmule. The gemmule is covered by a single, more or less regularly arranged layer of perpendicularly placed gemmule spicules embedded in the coat of granular substance around its entire surface. The outer surface of the coat has a pitted appearance, the pits being caused by the outer rotules of the birotulates which are almost even with the outer surface of the gemmule coat. The gemmules are very variable in size, ranging from 467 to 637 microns and averaging around 510 to 540 microns in diameter.

Gemmule spicules.—The gemmule spicules are birotulates of varying length, the extremes varying from 46 to over 70 microns,

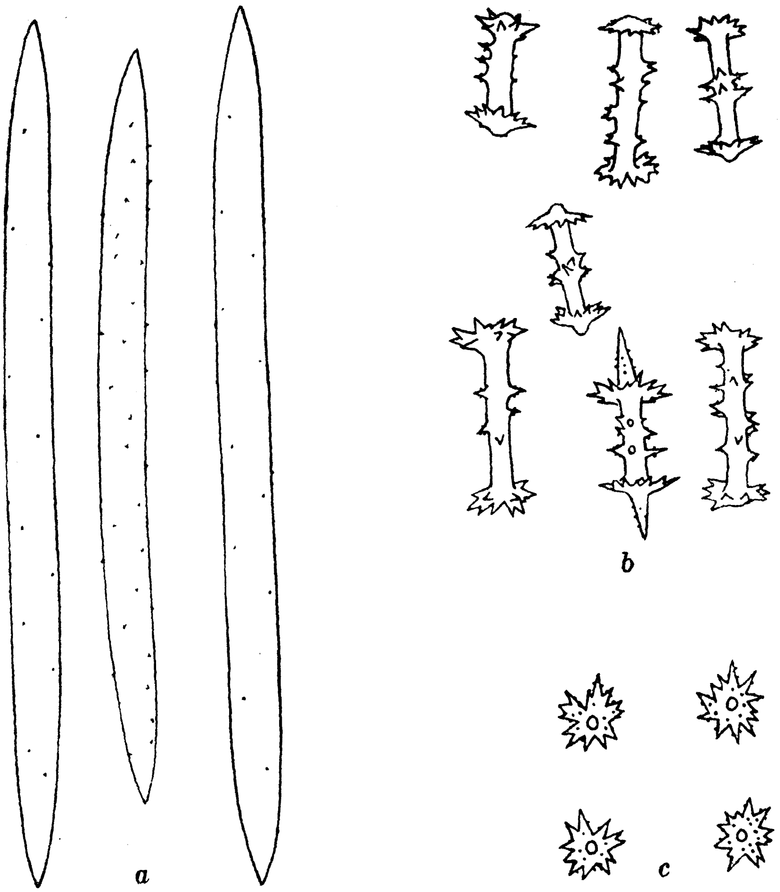

FIG. 5. *Ephydatia fortis* var. *vorstmani*, spicules; *a*, skeleton spicules; some almost smooth, some with larger numbers of minute spines; *b*, gemmule spicules, showing the wide range of variation in size and in arrangement of spines on the shafts of the various types; *c*, rotules or disks, showing indentations in edges; these bear very minute spines.

though the average is between these. The shafts are heavy, measuring 9 or 10 microns in diameter; the rotules are about equal and range from about 24 to 29 microns in diameter. The rotules are incised into coarse teeth and these are often finely spined near their tips. The shaft projects slightly beyond the plane of the rotule, forming small rounded knobs at each end of the birotulate; in a few cases this knob becomes elongated into a heavy, long, sharp spine at one or both ends. The shaft is provided with a variable number of heavy, conical, perpendicular spines which in turn bear small spines near their ends. Usually these heavy spines are more abundant around the central part of the shaft. The shaft spines may be simple or compound and may vary greatly in number and in size; some birotulates may have only three or four spines arranged nearly in a circle around the center of the shaft, others may have a large number of spines scattered irregularly along most of the length of the shaft; in most cases the spines do not occur close to the rotules; a rare spicule may now and then be found without any spines on its shaft.

Type.—The type of this variety is preserved in the collections of the Zoölogical Museum in Buitenzorg, Java.

Distribution.—So far, this variety has been found in Java in Klakah Lake and in Pakis Lake. The type form of this species, *Ephydatia fortis,* was originally described from the Philippines (Libmanan River, Luzon), and now we report the finding of the variety *vorstmani* in the collection made in Pinagbuhatan in January, 1932. Another variety of this species, *Ephydatia fortis* var. *hebridensis,* has been found in the New Hebrides Islands.

Remarks.—This sponge is definitely of the *Ephydatia fortis* group and resembles most closely the variety which the writer has described from Java, *Ephydatia fortis* var. *vorstmani.* It differs from that variety in the following details:

SKELETON SPICULES

1. Those of the Philippine sponge are in most cases either smooth or very sparsely covered with very minute spines; while those of the Java sponge are usually thickly covered with larger spines except near their ends.
2. Those of the Philippine sponge are more nearly straight than those of the Java sponge.

GEMMULE SPICULES

1. The gemmule spicules of the Philippine sponge are more normal and more regular in their development and have a more constant arrangement of the spines near the central area of the shaft than is the case in the spicules of the Java sponge.

Upon the first hurried examination of the Pinagbuhatan sponge, it seemed to be a form quite distinct from any *Ephydatia* with which the writer is familiar, but later careful comparisons of it with the Java sponge, *Ephydatia fortis* var. *vorstmani,* have convinced me that these two sponges, whose extremes are quite unlike, are connected by intervening links. While possibly the extreme forms of these two sponges are definite enough to merit varietal distinction in themselves, yet since it is possible to connect these extremes by a series of forms linking them together, a new varietal distinction cannot be made.

The variation of the skeleton spicules in these sponges presents a case similar to that of the sponges formerly known as *Ephydatia mulleri* and *E. japonica*, which are now considered as one species.

DOSILIA PLUMOSA (Carter), 1849. Figs. 6 and 7.

Spongilla plumosa CARTER, 1849.
Meyenia plumosa (CARTER), 1881.
Ephydatia plumosa WELTNER, 1895.

Historical statement.—Carter[20] described *Dosilia plumosa* from Bombay, India, and, many years later, revised his first description.[21] Specimens were submitted to Bowerbank and he published his description in 1863.[22] Potts quotes Carter's description in his monograph of the known sponges.[23] Annandale[24] redescribed the species in 1911. In this place he records having found this species at Rhambha in the northeast of the Madras Presidency.

I have now found this sponge in the material submitted to me by Mr. McGregor for examination both from Pasig River, near Manila, and from Pinagbuhatan, Rizal, Luzon, P. I. There was only a small fragment of the sponge in the Pasig River collection and it was at first overlooked, but after it had been found in three or four small bits in the Pinagbuhatan collection, the one small specimen was readily picked out of the accumulated "scraps" from the Pasig River collection.

In 1885 Potts described a variety, *palmeri*, of this species from the Colorado River, near Lerdo, Sonora, in northwestern Mexico, in the Proceedings of the United States National Museum; and Traxler in 1895, in Földtani Közlony, found the spicules of this variety in some alluvial soils from near São Paulo, Brazil.

In 1906, Kirkpatrick described another variety, *brouini*, from the White Nile River about two hundred miles north of Khartum, Africa.

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[20] Ann. & Mag. Nat. Hist. II 4 (1849) 85.

[21] Ann. & Mag. Nat. Hist. V 7 (1881) 94.

[22] Proc. Zool. Soc. London (1863) 449.

[23] Proc. Acad. Nat. Sci. Philadelphia (1887) 233.

[24] Fauna British India, Freshwater Sponges, Hydroids, & Polyzoa (1911) 111–113.

Habitat.—All of the small bits of this sponge which were found in the Philippine Islands collections except one were broken loose from their supports. The one small specimen was growing around a twig. I have no information concerning the place where these specimens were found. Carter found his specimens in tanks; Annandale found his in a pool of slightly brackish water.

General characteristics.—The specific name, *plumosa,* is descriptive and indicates the general feathery appearance of the sponge when it is growing freely. This was very characteristic of two or three of the small specimens, while one somewhat

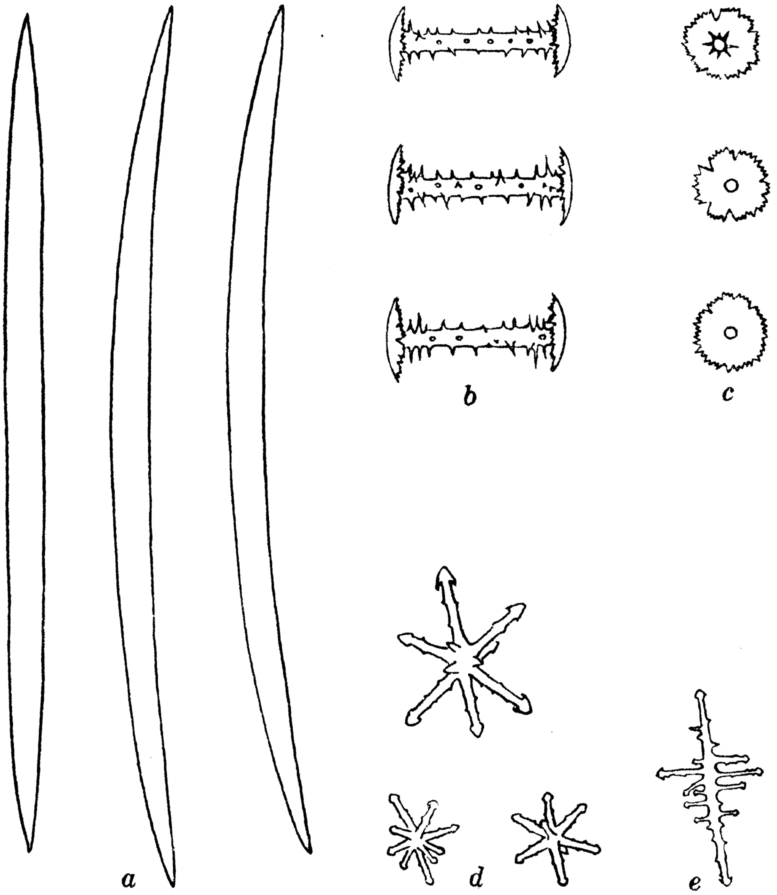

FIG. 6. *Dosilia plumosa,* spicules; *a,* skeleton spicules, smooth and sharp; *b,* gemmule spicules (birotulates), showing arrangement of spines on shaft; *c,* disks, showing indentations of edges; *d,* various types of the peculiar stellar flesh spicules; *e,* flesh spicule with one long main axis.

larger piece had evidently been mashed together while still wet into a compact mass. The largest specimen in the lot was growing around a small branched twig and covered it with an open, loose and, when dry, very brittle sponge for a length of about 6.5 centimeters. Its greatest diameter was something less than 2 centimeters in the center, and it tapered off to a thin covering of its support at each end. The one branch of the twig was also similarly covered by the sponge. Gemmules were scattered irregularly all through the sponges.

Color.—Carter's Bombay specimens were some green and some yellow; Annandale's were of a pale brown or a brilliant green. The Philippine specimens are all green. The difference in color is doubtless due to whether or not the position of the sponge is favorable for the growth of the algæ which are the cause of the color.

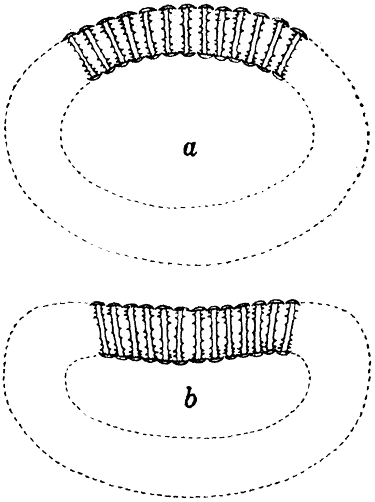

FIG. 7. *Dosilia plumosa;* diagrammatic sections of two types of gemmules, showing arrangement of birotulates which cover them.

Structure.—The skeletal structure of this sponge is unique. The radiating fibers are prominent and divide frequently in such a manner that they form a loose featherlike growth with a good deal of open space in it. These radiating fibers are formed of several spicules tightly bound together by an abundance of spongin and the fibers often extend to the surface of the sponge where they end in points, thus giving the surface of the sponge a hispid appearance. The smaller cross fibers binding the larger ones together are not nearly so conspicuous as the main ones.

Skeleton spicules.—The skeleton spicules are spindle-shaped, thicker in the center and gradually tapering to sharp points at each end. They are smooth and usually gently curved, though at times straight. The mature spicules vary from 416 to 527 microns in length and from 14 to 20 microns in diameter in the center. There are also a number of smaller smooth spicules, thinner and shorter, scattered throughout the parenchyma of the sponges; these are doubtless immature skeleton spicules.

Flesh spicules.—The flesh spicules are scattered in great abundance throughout the sponge, but seem to be especially numerous around the gemmules. The most common form of this spicule, which is the characteristic upon which the genus is founded, is an irregularly stellate one. There are often as many as eight to twelve or more rays of varying length projecting from a distinct central nodule. The radii vary considerably in length; some barely project beyond the surface of the central nodule, others seem to form a regular axis running straight through the nodule and measure as much as 36 microns from one end to the other. Most of the stellate spicules are smaller than this. These rays may be smooth or may bear small spines and end in slightly enlarged nodules bearing small recurved spines, sometimes forming an indefinite rotule. There is very great variation in these spicules and some rare ones are found which are straight, heavily spined ones with one or more large "spines" or branches projecting at right angles to the length of the spine; these do not have the central nodule. In other cases the stellate forms seem to be built upon such a straight spicule by adding the nodule around the perpendicular branches. It seems that the unique stellate form of spicule may have evolved from the straight one and doubtless it would be possible, by examining a very large series of slides, to discover the various stages of such an evolution.

The spines on the rays of the Indian sponge and at their ends are much larger and more abundant than those in the Philippine one.

Gemmules.—The gemmules occur singly and are scattered irregularly throughout the skeleton of the sponge. In my specimens they are fairly abundant. They are elliptical or ovoid in shape and, when dry, become flattened laterally. The pore tube, as a rule, is in the center of the flattened side and is a simple tube through the gemmule coat. The entire surface of the gemmule is covered by a granular coat in which are embedded a single layer of the long perpendicularly placed birotulates, with one rotule resting on the gemmule surface and the outer one forming part of the outer surface of the gemmule coat. Five gemmules chosen at random gave the following measurements in microns: 705 by 450.5, 688.5 by 450.5, 663 by 561, 765 by 450, 646 by 382.5.

Gemmule spicules.—The gemmule spicules are birotulates with rotules equal in size and very similar in structure. The disks are curved, concavo-convex, with the concave side toward the shaft. They are incised around their edges into numerous small, rather blunt, toothlike projections, which are slightly curved inward toward the shaft. The shaft is cylindrical, long, straight, rarely gently curved, and of almost uniform diameter except at the ends where it becomes swollen, trumpetlike, as it joins the rotules. It is covered with numerous spines throughout its length right up to the rotules. These spines are conical and sharp pointed and vary in size from very small ones to others with a length even greater than the diameter of the shaft itself. As a rule the spines in the center of the shaft are shorter than those near the rotules.

In the Indian sponge the shaft, as a rule, bears fewer and heavier spines; also the spines are generally located more toward the center of the shaft while the ends near the rotules are freer from them. The variation in length of the spicules is more marked in the Indian than in the Philippine sponge.

The spicules vary in length from 66 to 80 microns (the Indian sponge varies from 50 to 86 microns) and in thickness from 3 to 4 microns. The rotules vary from 23 to 25 microns in diameter.

Type.—Carter's type of this species from Bombay, India, is preserved in the British Museum in London, England.

Distribution.—As stated above, the type form of this sponge has, up to the present, been found only in Bombay and in Rhambha, near Madras, India. This being the case, the finding of this species in the Philippine Islands is of great interest. Doubtless it will be found later in the intervening areas. The two Philippine localities, Pasig River, near Manila, and Pinagbuhatan, Rizal Province, are not far apart. We will study with great interest additional collections from other more-distant localities, for doubtless there is a very rich and varied fresh-water sponge fauna in these Islands.

The two other described varieties of this sponge (Annandale, 1911, considered them as species) are from a very wide range of localities; *brouini* from the White Nile in Africa and *palmeri* from Sonora, Mexico, and from São Paulo, Brazil.

Remarks.—There are certain minor differences between the Indian sponge and the one from the Philippines. I have noted these above, but do not think them constant enough or so marked as to warrant the creation of a new variety. I find such great variation in sponges that I am more inclined now than I formerly was to "lump" rather than to "split" forms. It seems, however, in our present imperfect knowledge of the distribution of sponges that it may be wise to have some system of nomenclature in this group similar to the trinomial system in use in some other phyla to indicate widely isolated forms which show even slight variation from the type forms.

TROCHOSPONGILLA LATOUCHIANA Annandale, 1907. Fig. 8.

Historical statement.—This species was originally described and illustrated by Annandale.[25] The type specimen was collected in the tank of the Indian Museum in Calcutta. Since that time the species has been found rather widely distributed in the Orient, and it has been redescribed a number of times by different authors. Annandale's description in his Fauna of Indian volume (1911) and the present writer's description [26] give full information concerning the sponge.

A variety of this species, *Trochospongilla latouchiana* var. *pasigensis*, has already been described.[27] This differs considerably from this typical form which is now reported for the first time from the Islands.

Habitat.—This sponge is very common in Kiangsu and Chekiang Provinces, on the eastern coast of China, and is found growing in thin layers on all kinds of supports; such as, stones, wooden piles, and plant stems. It is very common in some localities in the canals where the water has some current. The specimens collected in Pinagbuhatan had grown on plant stems, usually small ones, or small twigs and formed typical colonies entirely covering the support.

General characteristics.—There are almost no differences in general appearance between the Philippine specimens and those from China except in the supports upon which they grow. The specimens in this Philippine collection cover plant stems or twigs, while most of the China ones grew on stones. In one of the Philippine specimens the sponge covered a flattened stick over 24 centimeters long by 3.5 by 1.5 centimeters with a uniform growth varying from 2 to 3 millimeters in thickness. In one small specimen the sponge is as much as a centimeter thick. In practically all of our China specimens of this sponge, there is present a large number of white gemmules; the gemmules are less abundant in the Philippine Islands specimens and are altogether lacking in some of them. The surface of the sponge when dry is hispid and suggests the surface of velvet. The pores are inconspicuous, but there are a number of branching canals running back and forth within the sponge; these can be clearly seen from the surface of the dried sponge.

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[25] Journ. Proc. Asiatic Soc. Bengal n. s. 3 (1907) 21–22.

[26] Treubia 12 (1930) 98–101.

[27] Philip. Journ. Sci. 48 (1932).

Color.—The general color of these sponges is brown, varying from a lighter brown in the cleaner specimens to a darker color in those which contain more sediment. It is evident that sponges growing in clean water free from sediment would be light brown. The gemmules are white.

Structure.—The skeleton of this sponge is made up of clearly defined, stout fiber rays consisting of several spicules placed perpendicularly to the support, branching repeatedly, continuing to the surface of the sponge and terminating in sharp points

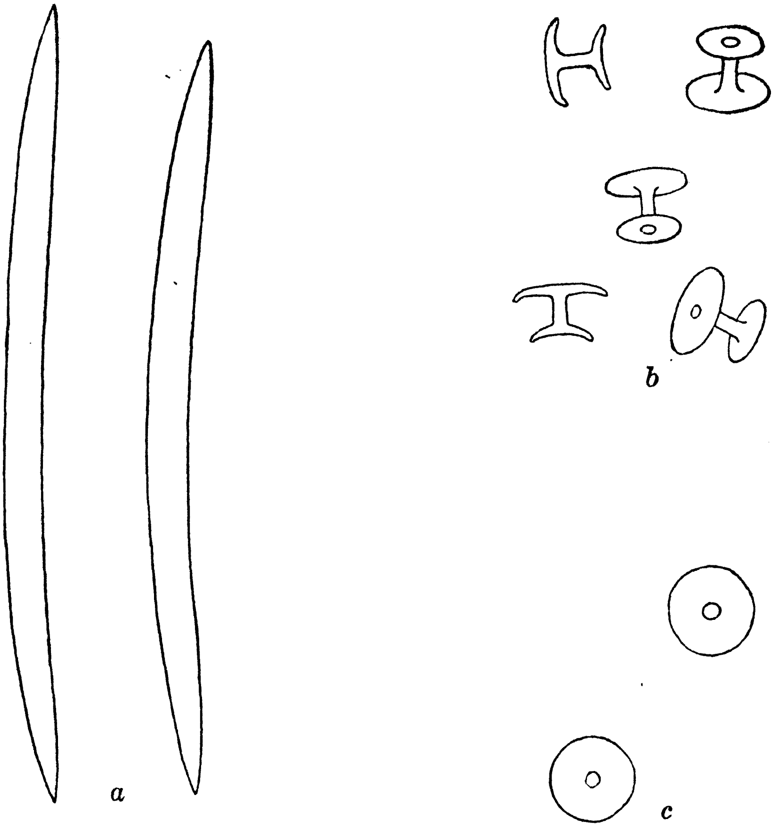

FIG. 8. *Trochospongilla latouchiana*, spicules; *a*, smooth, gently curved skeleton spicules; *b*, gemmule spicules with edges of the disks upturned; *c*, smooth-edged disks.

which give the sponge its velvety appearance. The spongin is moderate in amount, but it binds the fibers tightly together and gives a rigidity to the entire structure. The transverse fibers are less regular and are thinner than perpendicular ones.

Skeleton spicules.—The skeleton spicules are usually gently curved, rarely straight, smooth, spindle-shaped, being thicker in the center and gradually tapering to sharp points at each end. They are, as a rule, from 246 to 297 microns in length and from 10 to 15 microns in diameter. The slide preparations have now and again a few spicules as long as 332 microns and as thick as 20 microns; it seems likely that these are the spicules from another sponge, possibly *Spongilla carteri,* mixed with those of *Trochospongilla latouchiana.*

Flesh spicules.—This species does not have any flesh spicules.

Gemmules.—The gemmules are white, small, and nearly spherical. They are scattered singly throughout the meshes of the sponge and have no definite arrangement. The pore tube is simple and opens through the single layer of birotulates, sometimes with this layer arranged into a craterlike structure around its opening. The birotulates are perpendicularly placed with the larger rotule resting upon the surface of the gemmule, the rotules being so crowded together that their edges may even overlap a bit at times. The smaller rotules are about even with the outer surface of the gemmule coat and frequently cause it to have a pitted appearance because of the curved rotule. The gemmules of Philippine sponges will probably average somewhat smaller than the China ones, but the range of variation in diameter is very nearly the same; they measure from 174 to 196 microns in diameter.

Gemmule spicules.—The gemmule spicules are collar-button-like birotulates bearing flattened disks of unequal size and with their edges turned up in a saucerlike manner. The shaft is small, slender, and free from spines; it becomes slightly enlarged toward each end as it joins the disks. The length of the spicules varies from 16 to 17 microns, outside measurement. This length is more constant and closer to that of the typical form in the Philippine sponges than is the case in a great many of the Chinese sponges of this species. The upper rotule is from 14 to 15 microns in diameter, and the lower one is about 18 microns; the shaft is approximately 3 microns thick.

Type.—The type of this species is kept in the Indian Museum, Calcutta, India.

Distribution.—*Trochospongilla latouchiana* has been previously reported from Calcutta and neighborhood, lower Bengal, India; from Kawkareik, Lower Burma; from the Botanical Garden in Buitenzorg and from a lake at the station of Tjitajam in West Java; also from Galapan Lake in East Java; from several places in both Kiangsu and Chekiang Provinces in east-central China. From the materials in this collection now under study the range is being extended to the Philippine Islands. There are several specimens of this species in the collections made in Pinagbuhatan, Rizal, Luzon, but it has not yet been found at the other places from which collections have been made.

Remarks.—It seems quite likely that this sponge will be found to occur under suitable conditions in most of the region between India and the Philippine Islands when careful studies of that region have been made. Forming, at it does, thin inconspicuous coverings upon its supports, it is likely to be overlooked except by experienced collectors. The range of this species in China so far as we now know it is rather interesting; Nanking in the southern part of Kiangsu is its northern limit and the southern portion of Chekiang Province is its southern limit. Collections have not been made in the interior provinces of China, and we may yet find that the distribution is more general and covers a much wider range than is indicated from our present knowledge.

TROCHOSPONGILLA PHILLOTTIANA var. TUNGHUENSIS Gee, 1926. Fig. 9.

Trochospongilla tunghuensis GEE, 1926.

Historical statement.—*Trochospongilla phillottiana* was first described and illustrated by Annandale,[28] from specimens collected in the tank of the Indian Museum in Calcutta, India. The variety *tunghuensis* of the type species was described by the writer from material secured from Tung Hu (East Lake), near Ningpo, China, in 1925. A brief description first appeared in 1926;[29] since that time several redescriptions of the variety have appeared, the last in the writer's monograph on the genus *Trochospongilla*.[30]

Habitat.—This sponge has only been found in China occurring on colonies of other sponges. It is very rare and was found in several cases around the edges on the underside of pieces of

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[28] Journ. Asiatic Soc. Bengal n. s. 3 (1907) 22–23.

[29] China Journ. Sci. and Arts (1926) 171.

[30] Peking Nat. Hist. Bull. 6 pt. 2 (1932) 1–32.

Spongilla fragilis which had been collected on the Van Nyien Jao, Soochow. The related variety, *javanensis*, was found growing in very small patches on small rootlets in Rawah Bening, East Java. The Philippine representatives were collected in Pinagbuhatan, Rizal, growing on fine rootlets or twigs.

General characteristics.—The colonies of this species found in Pinagbuhatan are the largest that I have seen; they form small nodules from 1 to 2 centimeters in length and have a thickness of 2 to 3 millimeters in the center of the colony all around the support and become thinner until they end in a mere film covering the support. If the twig has a diameter of 3 or 4 millimeters, then the sponge colony may measure as much as 2 centimeters in length and 6 to 8 millimeters, or slightly more, in diameter in its thickest part. The surface is smooth.

Color.—When dry, these sponges are gray with a slight brownish tinge; some of them have a dirty white appearance.

Structure.—The colonies are so small and so thoroughly crowded with gemmules that the sponge shows no distinguishing structure; the irregular system of meshwork seems woven together simply to hold the gemmules in place and there are no distinct, continuous fibers which extend throughout the sponge. The spicules are short and the fibers are thin and irregular, composed usually of only a very few spicules held together by a small amount of spongin. The whole structure is fragile and crumbles very easily.

Skeleton spicules.—Most of the skeletal spicules are curved, straight ones are very rare, thickly covered all over, even to the very tips, with very fine, sharp spines. The spicules are mainly splindle-shaped, some of them slender, measuring only 4 to 5 microns in diameter and tapering very gradually to sharp-pointed ends; others are thicker, measuring up to 13 microns, and of a more uniform diameter throughout most of their length, but abruptly sharp pointed or in some few cases with nearly rounded ends except that there is a small sharpened point at the tip. The spicules vary in length from around 153 to 192 microns.

Flesh spicules.—There are no flesh spicules in this species.

Gemmules.—The nearly spherical gemmules are white, occur singly, and are crowded through most of the sponge body. They are covered with a more or less translucent jellylike substance, which forms a very irregular "bubbly" coat over the entire surface of the gemmule giving it a pitted appearance.

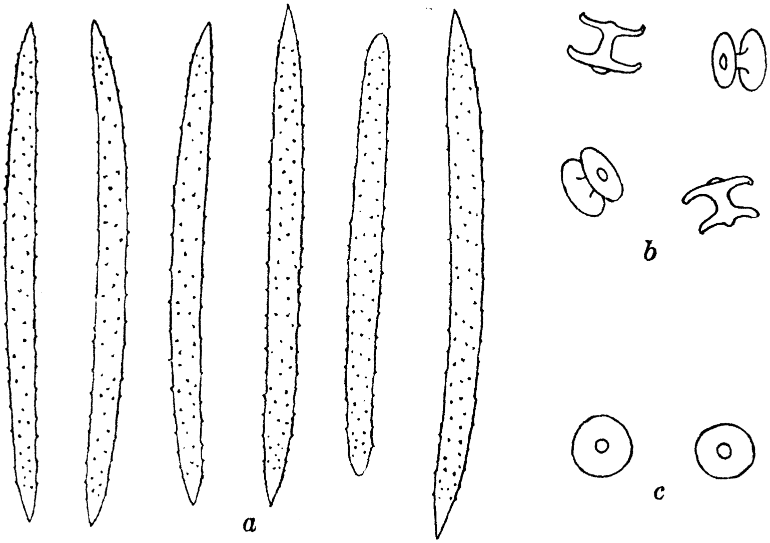

FIG. 9. *Trochospongilla phillottiana* var. *tunghuenis*, spicules: *a*, sharp-pointed, spined skeleton spicules; *b*, small birotulates with curved disks and small umbos; *c*, circular disks with smooth edges.

In this are embedded numerous dark-colored particles which may be minute unicellular algæ. Inside this outer coat, there is a single layer of gemmule spicules arranged so closely together that their rotules often overlap. The pore tube is simple. The gemmules are all dry and, in most cases, one-half of them is shrunken in forming a bowl-like structure. The gemmules vary from 255 to 273 microns in diameter when naked, but when including the jellylike covering they measure from 270 to 323 microns in diameter.

Gemmule spicules.—The gemmule spicules are small birotulates with a comparatively thin shaft and smooth-edged rotules; the rotules are large for the size of the spicule and are of more nearly equal diameters than are those of *Trochospongilla latouchiana.* The lower rotule or disk is usually slightly larger than the upper one; both rotules are curved upward around their outer edges forming saucerlike disks, sometimes their edges are a bit sinuous. The shaft forms a very small knob on the outer surfaces of the disks. The length of the spicules is about 10 to 12 microns; the diameter of the upper rotule is from 16 to 17 microns and that of the lower one slightly greater, from 17 to 20 microns.

Type.—The type of this variety is No. 53666 in the writer's collection.

Distribution.—It seems quite likely that this sponge and its related forms may be quite widely distributed over the area between India, Japan, and the Philippine Islands. Up to date this special variety has been recorded from the following places in China: East Lake (Tung Hu), near Ningpo, Chekiang Province; Soochow and Nanking, both in Kiangsu Province; and Tung Ting Lake, near Yochow, Hunan Province. It has also been found by the writer in Lake Biwa, Japan. Now this interesting collection from Pinagbuhatan is also found to contain it. A closely related variety, *javanensis,* of this species has been found in Java. The type form, *Trochospongilla phillottiana,* is known only from Calcutta, India, and the writer has described a very small variety, *minima,* of this species from Kawkareik in lower Burma.

The sponge colony is so minute in size that it is easily overlooked and only experienced collectors are likely to notice it. When a more careful and detailed study of the sponge fauna of this region is made doubtless many of the smaller forms which are now overlooked will be brought to our attention.

Remarks.—In the sponges of this variety, both from China and from Japan, there are a number of skeleton spicules with distinctly rounded ends, but in the Philippine representatives of this group I have not found more than five or six skeleton spicules without the trace of a sharp point at their ends. In those sponges where both the sharp and the round-ended spicules occur, nearly always the sharp-pointed ones average somewhat longer than those with round ends.

Trochospongilla phillottiana var. *minima* from Burma has markedly smaller spicules, both skeletal and gemmule, than any of the others of the *Trochospongilla phillottiana* group, but the other forms, while there are variations one from the other, yet closely resemble each other in the dimensions of their skeletal and gemmule spicules. It is probably better for the present to maintain the described varieties; it will be noticed that all the sponges of this group from China, Japan, and the Philippine Islands are placed in the same variety, *tunghuensis.*

ILLUSTRATIONS

[Drawings by Y. C. Su, made under the direction of Dr. C. F. Wu, of Yenching University.]

TEXT FIGURES

FIG. 1. *Spongilla proliferens*, spicules; *a*, smooth skeleton spicules; *b*, gemmule spicules, showing heavy, recurved spines near the ends and the divided or multiple-pointed spines in the middle area of the spicules; *c*, the small sharp-pointed flesh spicules.

2. *Spongilla carteri*, spicules; *a*, smooth skeleton spicules; *b*, very similar, but smaller, gemmule spicules.

3. *Spongilla fragilis* var. *decipiens*, spicules; *a*, smooth skeleton spicules, abruptly sharpened; *b*, longer gemmule spicules, showing various shapes and the variety in the size and arrangement of the spines; *c*, shorter gemmule spicules.

4. *Ephydatia crateriformis*, spicules; *a*, spined skeleton spicules; *b*, gemmule spicules; some with sharp ends, others with rounded ends.

5. *Ephydatia fortis* var. *vorstmani*, spicules; *a*, skeleton spicules; some almost smooth, some with larger numbers of minute spines; *b*, gemmule spicules, showing the wide range of variation in size and in arrangement of spines on the shafts of the various types; *c*, rotules or disks, showing indentations in edges; these bear very minute spines.

6. *Dosilia plumosa*, spicules; *a*, skeleton spicules, smooth and sharp; *b*, gemmule spicules (birotulates), showing arrangement of spines on shaft; *c*, disks, showing indentations of edges; *d*, various types of the peculiar stellar flesh spicules; *e*, flesh spicule with one long main axis.

7. *Dosilia plumosa;* diagrammatic sections of two types of gemmules, showing arrangement of birotulates which cover them.

8. *Trochospongilla latouchiana*, spicules; *a*, smooth, gently curved skeleton spicules; *b*, gemmule spicules with edges of the disks upturned; *c*, smooth-edged disks.

9. *Trochospongilla phillottiana* var. *tunghuensis*, spicules; *a*, sharp-pointed, spined skeleton spicules; *b*, small birotulates with curved disks and small umbos; *c*, circular disks with smooth edges.

RECENT AND FOSSIL SHELLS FROM THE PHILIPPINE ISLANDS, I

By LEOPOLDO A. FAUSTINO

Of the Bureau of Science, Manila

TWO PLATES

This is the first of a series of papers on Recent and fossil shells of the Philippine Islands, and is for the purpose of describing and figuring new or interesting shells, also those contained in the writer's Summary of Philippine Marine and Fresh-water Mollusks [1] and in his Summary of Philippine Land Shells,[2] and other shells which have recently been collected or acquired by purchase or exchange and now form part of the conchological collection of the Bureau of Science together with fossil forms which have been collected by the Bureau of Science and other scientific institutions. Original descriptions of shells first described from the Philippine Islands will be given whenever they are available to the writer, with notations on the type locality. The geographic and geologic range of the genera and some of the species will also be given. It is the aim to make this series useful to the amateur, the professional conchologist, and the palæontologist.

In the preparation of this series the writer has received help from all sources, but he wishes to make special acknowledgment of the help given him by Dr. Paul Bartsch, curator of Cenozoic invertebrates, United States National Museum, Washington; Mrs. Ida S. Oldroyd, curator of the Conchological Museum, Leland Stanford Junior University, California; the British Museum of Natural History and Mr. H. C. Fulton, London; Dr. B. Rensch, of the Zoologisches Museum der Universität Berlin; Dr. F. Haas, of the Senckenberg Museum, Frankfurt-a-Main; Dr. B. Prashad, of the Zoological Survey of India, Indian Museum; and the Australian Museum, Sidney.

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[1] Bur. Sci. Mon. 25 (1928) 1–384.

[2] Philip. Journ. Sci. 42 (1930) 85–198.

To the long list of references on Philippine shells given in the writer's enumeration, the following should be added:

16a.[3] In American Journal of Conchology, George W. Tryon, Jr., published two papers which describe two Philippine shells.

Descriptions of new species of Melania 1 (1865) 216–218.
Descriptions of new species of Amnicola, Pomatiopsis, Somatogyrus, Gabbia, Hydrobia, and Rissoa 1 (1865) 219–222.

28a. In the Proceedings of the Malacological Society of London the following papers were published:

On some new species of Melania from Palawan and the neighborhood 1 (1893) 175–177. A Brot.
On Monodonta quadrasi n. s., belonging to the subgenus Austrocochlea, from the Philippine Islands 3 (1898) 9. G. B. Sowerby.
Description of Tridacna obesa n. s., from the Philippines 3 (1898) 210. G. B. Sowerby.
Description of new species of marine mollusca collected by the late Otto Koch at the Island of Cebu 4 (1900) 126–129, 208–211. G. B. Sowerby.
Note on the opercula of Turbo pulcher Reeve and T. ticaonicus Reeve 5 (1902) 12. G. B. Sowerby.
Descriptions of new species of land shells from Peru and Colombia and two new species of Curvella from the Philippine Islands 7 (1906) 97–99. S. I. da Costa.
Notes on the shells of Tridacna, and description of a new species 10 (1912) 30. G. B. Sowerby.
On a collection of Pelecypoda from the Philippine Islands 12 (1916) 12–19. E. A. Smith.
Descriptions of new species of Mollusca belonging to the genera Drillia, Clavatula, Epitonium, Cantharidus, Bittium, Fissurella, and Cardium 12 (1916) 74–76 G. B. Sowerby.

32b. The latest contributions of Paul Bartsch to Philippine conchology are, New and old land shells from the Island of Luzon, Philippines, No. 2848, Proc. U. S. Nat. Mus. 78 (1930) 1–20, pls. 1–9; The tree snails of the genus Cochlostyla of Mindoro Province, Journ. Washington Acad. Sci. 22^{12} (1932) 335–344; The Philippine land mollusks Cochlostyla rufogaster and Obba marmorata and their races, Bull. U. S. Nat. Mus. 100, 6^{7} (1932) 329–342, pls. 83–86.

33. In the Proceedings of the United States National Museum, 57 (1921), W. H. Dall in his, Annotated list of the Recent Brachiopoda in the collection of the United States National Museum,

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[3] Numbers refer to those used in the Introduction to Bureau of Science Monograph 25.

described 14 new species of brachiopod shells from the Philippines.

34. Bryant Walker published his, Notes on certain Philippine species of Viviparus, in Nautilus (April, 1919) 1–16.

35. One of the Occasional Papers of the Boston Society of Natural History is, Land shells from Lubang Island, Philippines, by William J. Clench and Allan F. Archer 5 (1931) 333–339, pl. 17.

36. The Director of the Zoölogical Survey of India published several important papers relating to the molluscan fauna of the Philippines. These are B. Prashad's Recent and Fossil Viviparidae, Memoirs of the Indian Museum 8 (1928) 153–252, 1 pl. and Revision of the Asiatic species of the genus Corbicula III. The species of the genus Corbicula from China, South Eastern Russia, Tibet, Formosa, and the Philippine Islands, Memoirs of the Indian Museum 9 (1929) 49–68, 2 pls.

37. Systematic works on Philippine fossil shells to the present time are few. The following may be considered the most important:

Francisco Antonio Llanos, Fósiles marinos de Filipinas, Revista de los progresos de las ciencias 13 (1863). (Not seen.)

K. Martin, description of *Vicarya callosa* var. *semperi* Martin in "Concerning Tertiary Fossils in the Philippines," Sammlungen des geologischen Reichs-Museums in Leiden 5 (1896) 68–69, translated by George F. Becker as a complement to his paper, Geology of the Philippine Islands, Ann. Rept. U. S. Geol. Surv. 21^3 (1901) 643–644.

Warren D. Smith, Preliminary geological reconnaissance of the Loboo Mountains, Batangas Province, Philip. Journ. Sci. 1 (1906) 628–631.

Warren D. Smith, Contributions to the stratigraphy and fossil invertebrate fauna of the Philippine Islands, Philip. Journ. Sci. § A 8 (1913) 255–280.

I. Hayasaka, Magellania dickersoni, a new species of brachiopod, Philip. Journ. Sci. 27 (1925) 61.

DESCRIPTION OF SPECIES

Family ARCIDÆ Dall

ARCA BINAKAYANENSIS sp. nov. Plate 2, figs. 1 and 2.

Shell nearly square, thick, inequivalve, left valve extending beyond the right valve, sides angulated at the upper part, anterior somewhat rounded, posterior almost a right angle. White, covered with a thin brown scaly epidermis, which comes off easily, radiately ribbed, ribs 34, flat, fairly smooth, a few on the left valve somewhat larger than those on the right valve.

Length, 45 to 55 millimeters; height, 40 to 50.

Type.—No. 14046, Bureau of Science.

Locality.—Binakayan, Cavite, Philippines.

This is one of the common species sold in the Manila markets, and the Bureau of Science has hundreds of specimens. The type specimen was collected from the type locality by Florencio Talavera, of the division of fisheries, Bureau of Science. This species may be distinguished from *Arca cepoides* Reeve, its nearest ally, by the nearly right-angled posterior end and by its thicker shell.

Family OSTREIDÆ Lamarck

Genus OSTREA Linnæus

OSTREA IREDALEI sp. nov. Plate 1, figs. 1 to 4.

Shell somewhat variable in shape, depending largely on the object and mode of attachment. Those growing in bunches are elongate, sometimes tongue-shaped. Others are subtrigonal obliquely subtrigonal, sometimes oblong. Very foliaceous, and with a prominent beak.

Lower or left valve excavated, generally with a purple tint. Upper valve smaller, thinner, flatter, generally yellowish brown, sometimes with faint radiating rays of purple, covered with thin laminæ, scaly at the margins.

Hinge toothless, valve margins inside smooth. Shell interior chalky white. Muscle scar purple, located near the center.

Length, 30 to 80 millimeters.

Type.—No. 13594, Bureau of Science, collected by Florencio Talavera at Navotas, Rizal.

Locality.—Navotas, Malabon, Parañaque, and other places on Manila Bay.

Cotype.—No. 14259, Bureau of Science, collected by Florencio Talavera, at Parañaque, Rizal.

This species is the commonest oyster found near Manila and the one generally encountered in the Manila markets. I strongly suspect that this is the species referred to by Seale[3] as *Ostrea orientalis* Chemnitz, although as described by Dillwyn *O. orientalis* has a "shell about an inch and three quarters long, and an inch and a half broad." Unfortunately, the specimens of Seale could not be located in the Bureau of Science. Reeve's Conchologia Iconica mentions *O. orientalis* Chemnitz as "species not identified." The conchologist of the Australian Museum, Sidney, was the first one to call my attention to the fact that the commonest Manila oyster appears to be an undescribed species, very well characterized by the purple muscle scar and by the extremely chalky white interior.[4] After studying hundreds of available specimens in the collection of the Bureau of Science I am convinced that the commonest Manila oyster has been to the present time without a name. I take pleasure in naming this shell, *O. iredalei* in honor of the conchologist of the Australian Museum, Sidney, Mr. Tom Iredale.

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[3] Philip. Journ. Sci. § D 7 (1912) 273–281.

OSTREA MALABONENSIS sp. nov. Plate 2, figs. 3 to 5.

Shell not large, generally small, subtrigonal or irregularly oblong, solid, generally not found in bunches but attached singly to other objects or shells.

Lower valve concave, deep, plaited, plaits rounded, comparatively large, numerous. Upper valve, plain at the middle, but plaited at the margin, sometimes whole upper valve plain throughout.

Shell interior with greenish brown spots. Valve margins not smooth but toothed.

Length, 25 to 45 millimeters.

Type.—No. 14264, Bureau of Science.

Locality.—Malabon, Rizal, Philippines.

This small species is encountered with the preceding species, *O. iredalei,* and is very highly prized on account of its delicious flavor. It can easily be distinguished from *O. plicata* Chemnitz, which is compressed and striped or spotted with purple. *Ostrea malabonensis* is not compressed and is generally yellowish brown. If *O. palmipes* Sowerby can be identified by the exterior of the lower valve presenting the appearance of the webbed foot of a bird, *O. malabonensis* can likewise be identified by the horse's hoof appearance of its lower valve.

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[4] Personal communication from W. T. Wells, secretary of the Australian Museum.

ILLUSTRATIONS

[Drawings by Pio Moskaira.]

PLATE 1

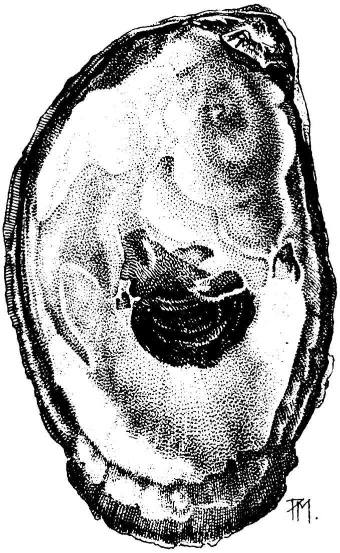
FIGS. 1 and 2. *Ostrea iredalei* sp. nov., cotype, × 1; 1, upper or right valve; 2, lower or left valve.

3 and 4. *Ostrea iredalei* sp. nov., type, × 5/8; 3, upper or right valve; 4, lower or left valve.

PLATE 2

FIGS. 1 and 2. *Arca binakayanensis* sp. nov., × 1; 1, right valve; 2, left valve.

3 to 5. *Ostrea malabonensis* sp. nov., × 1; 3, upper or right valve; 4 and 5, lower or left valve.



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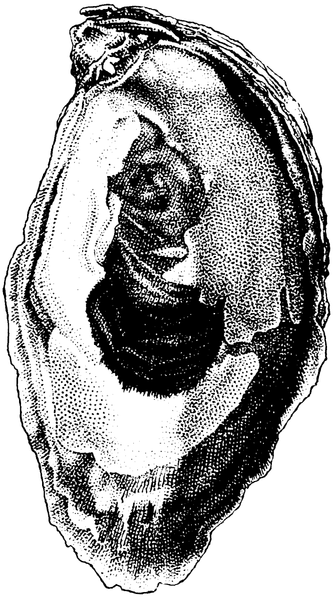

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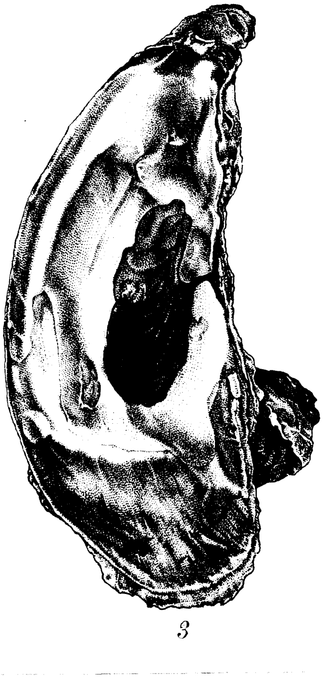

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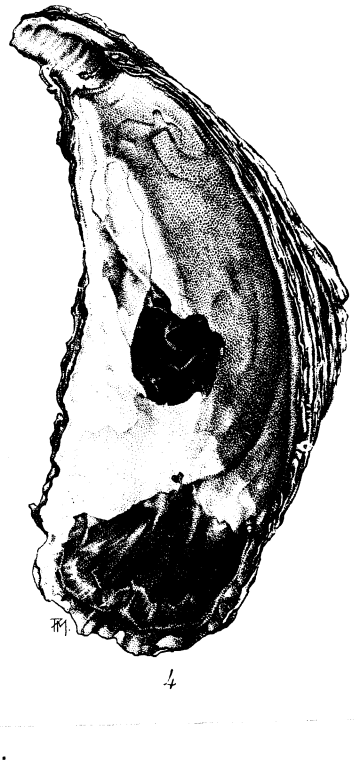

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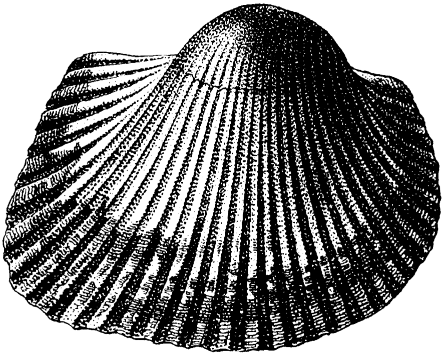
PLATE 1.



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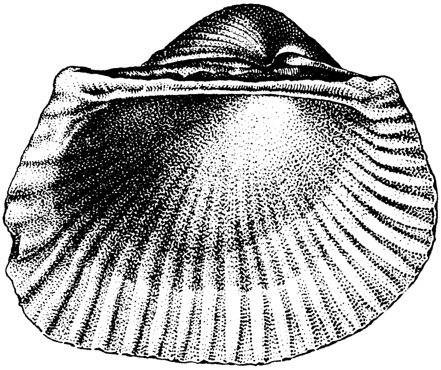

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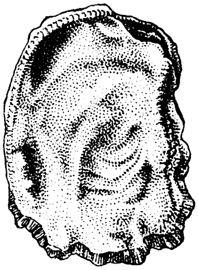

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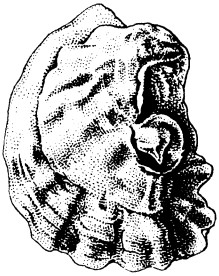

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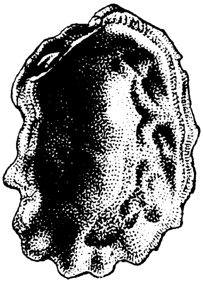

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PLATE 2.

EINE NEUE HYDROBIIDE VON DEN PHILIPPINEN

Von Bernhard Rensch
Zoologisches Museum der Universität Berlin

EINE TEXT FIGUR

Herr Dr. L. A. Faustino hatte die Freundlichkeit, mir eine Serie von Hydrobiidenschalen zur Bestimmung zuzusenden, die von Herrn Dr. M. A. Tubangui im Februar, 1932, bei Palo auf Leyte gesammelt waren. Die Untersuchung von Schalen, Deckel und Radula ergab, dass es sich um eine noch unbeschriebene Art handelt, die der ostasiatischen Gattung *Oncomelania* Gredler einzufügen ist.

ONCOMELANIA HYDROBIOPSIS sp. nov.

Diagnose.—Schale (Textabb. 1, *a*) glasig hellbraun, schlank kegelförmig, geritzt, genabelt, Apex stumpf; 6.5 bis 7 gewölbte Umgänge, der letzte davon mehr als die Hälfte der Gehäusehöhe einnehmend; Naht vertieft; Oberfläche fettig glänzend, mit feinen, etwas ungleichmässigen Zuwachsstreifen; Mundöffnung senkrecht, eiförmig, eben zugespitzt; unmittelbar hinter der Mündung eine gelbliche, wulstige Verdickung; Mundungsränder durch dicken Callus verbunden.

Höhe 4.2 bis 5.6 mm; Durchm. 2.5 bis 2.9 mm; Mündungshöhe 2.0 bis 2.2 mm.

Deckel glasig, mit zwei excentrisch gelegenen Windungen (vergl. Textabb. 1, *b*).

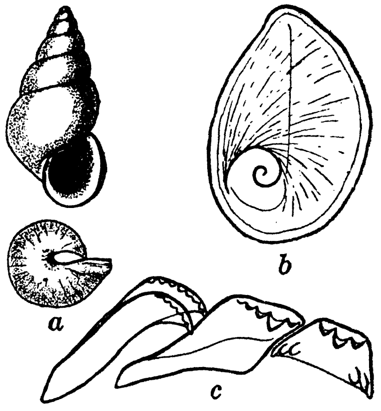

FIG. 1. *Oncomelania hydrobiopsis* sp. nov.; *a*, schale; *b*, operculum; *c*, radula.

Mittelzahn der Radula dreizackig und jederseits mit drei hinteren Spitzen an der Basalplatte (typisch für die Gattung *Oncomelania*). Der beiderseits folgende Zahn mit breiter lang ausgezogener Basalplatte und 6 Zacken, von denen die dritte von innen am längsten ist, der darauf folgende Zahn mit 8, der äusserste mit 5 oder 6 Zacken (Textabb. 1, *c*).

Die übrigen bekannten, in Japan, China und auf Formosa beheimateten *Oncomelania*-Arten sind sämtlich grösser als *hydrobiopsis*. Am ähnlichsten ist vielleicht *O. moellendorffi* (Schmacker and O. Boettger) von China, die ebenfalls einen starken Wulst hinter dem Mundsaum hat, aber flachere Umgänge, einen stichförmigen Nabel und viel derbere Skulptur besitzt. Die in der Schalenform ähnliche, aber erheblich grössere und schlankere *Hypsopia nosophora* Robson von Japan (ein Schistosomiasis-Ueberträger), hat einen fünfzackigen Mittelzahn und stärker excentrisch gewundenen Deckel.[1]

Ich verglich auch noch die zahlreichen in der Schalenform ähnlichen, indoaustralischen Schneckenarten, die vorläufig als *Assiminea* oder *Paludinella* bezeichnet werden, deren Radula aber noch nicht bekannt ist. Es stimmt jedoch auch von diesen keine mit der neubeschriebenen Art überein.

[1] Brit. Med. Journ. 1 (1915) 203, pl. fig. 7–9, text fig. 11.

ILLUSTRATION

TEXT FIGUR

FIG. 1. *Oncomelania hydrobiopsis* sp. nov.; *a*, schale; *b*, operculum; *c*, radula.

ENTOMOLOGICA MALAYANA BAKERI: EINIGE UNBESCHRIEBENE RHYNCHITINEN (COLEOPTERA, CURCULIONIDÆ)

25. BEITRAG ZUR KENNTNIS DER CURCULIONIDEN

Von EDUARD VOSS

Berlin-Charlottenburg, Deutschland

Die vorliegende kleine Abhandlung bringt einige Neubeschreibungen von Rhynchitinen aus der Sammlung des verstorbenen, hochverehrten Forschers Prof. C. F. Baker. Mit Ausnahme der ersten Art gehören alle folgenden dem Subgenus *Involvulus* an.

RHYNCHITES PALLICOLLIS sp. nov.

Kopf mit Augen breiter als lang, ziemlich kräftig und sehr dicht punktiert; Stirn und Scheitel kräftig und breit gefurcht. Augen stark vorgewölbt, länger als die Stirn breit; Schläfen parallelseitig, etwa so lang wie die Stirn breit. Rüssel kürzer als das Halsschild, kräftig, unten gerade, oben stumpfwinklig; basale Hälfte mit Mittelkiel, der sich vorn kurz gabelt. Fühler kurz, vor der Mitte eingelenkt; Schaft- und 1. Geisselglied gleichlang, länger als breit; 2. Glied etwas länger als das 1. Glied; 3. und 5. Glied so lang wie das 1. Glied; 4. und 6. Glied etwas länger als breit; 7. Glied so lang wie breit. Erstes und 2. Glied der Fühlerkeule gleichlang, jedes doppelt so lang wie breit; 3. Glied spindelförmig, fast anderthalbmal so lang wie das 2. Glied. Halsschild breiter als lang, konisch, schwach gerundet; Vorderrand durch eine scharfe Furche abgeschnürt. Punktierung mässig stark und dicht. Schildchen viereckig, hinten dreieckig ausgeschnitten. Flügeldecken so lang wie breit, parallelseitig. Punktstreifen kräftig; Zwischenräume schmaler als die Streifen, fein und dicht runzlig punktiert. Hintertibien auffallend lang und schlank, Mitteltibien kürzer, gleichmässig schwach gebogen.

Färbung rot; Halsschild heller rotgelb. Behaarung kurz, anliegend, wenig erhoben. Länge 3.5 mm.

BORNEO, Sandakan (*Baker, 13666*). In meiner Sammlung.

Die Art ist unter das Subgenus *Cartorhynchites* zu stellen.

RHYNCHITES RUFESCENS sp. nov.

Kopf quer, ziemlich fein und dicht punktiert; Stirn mit Eindruck, unpunktiert. Augen kräftig vorgewölbt, länger als die Stirn breit, Schläfen sehr kurz. Rüssel etwas kürzer als das Halsschild, schwach gebogen; ziemlich kräftig, im basalen Drittel oben mit Mittelkiel und je einer seitlichen Furche, im übrigen ziemlich kräftig und dicht längspunktiert. Fühler hinter der Rüsselmitte eingelenkt. Schaftglied etwas kürzer als das 1. Geisselglied; letzteres doppelt so lang wie breit; 2. und 3. Glied wenig kürzer als das 1. Glied; 4. Glied etwa anderthalbmal so lang wie breit. Fünftes und 6. Glied etwas länger als breit; 7. Glied so lang wie breit. Erstes und 2. Glied zusammen etwa so lang wie die Geissel, kräftig, jedes gut anderthalbmal so lang wie breit. Halsschild so lang wie breit; seitlich ziemlich kräftig gerundet, die grösste Breite liegt hinter del Mitte, am Vorderrand schmaler als an der Basis. Punktierung gleichmässig fein und dicht, feiner als diejenige des Kopfes. Schildchen viereckig, fein und sehr dicht punktiert. Flügeldecken fast anderthalbmal so lang wie breit, von den Schultern schwach geradlinig bis über die Mitte hinaus verbreitert, dann in gleichmässigem Bogen zugerundet. Punktstreifen vorn sehr kräftig, hinten viel feiner, der Nahtstreif im basalen Teil breit furchenartig; Zwischenräume vorn schmaler und etwa vom basalen Drittel ab breiter als die Streifen, sehr fein und mässig dicht unregelmässig punktiert. Pygidium fein und sehr dicht punktiert, ebenso die Hinterbrust (besonders im hinteren Teil), mit Seitenteilen. Tibien kräftig, die Mitteltibien am kürzesten, gebogen; Schenkel kräftig.

Färbung rot; Fühlerkeule sowie das letzte Geisselglied schwarz. Behaarung kurz, dicht, geneigt, untermischt mit längeren abstehenden Haaren; auch Abdomen und Tibien abstehend gelb behaart, Mittel- und Hinterbrust sparsamer anliegend behaart. Mittel- und Hinterschenkel aussen mit einer Doppelreihe feiner schwarzer Punkte saumartig besetzt. Länge 3.6 mm.

BORNEO, Sandakan (*Baker, 13954*). In meiner Sammlung.

Von *R. nigriclavatus* m., dem die vorliegende Art am nächsten steht, ist sie durch die sehr dichte Halsschildpunktierung sowie durch den kürzeren Rüssel zu unterscheiden.

RHYNCHITES SUBVIRENS sp. nov.

Weibchen.—Kopf gleichmässig sehr dicht, fast runzlig punktiert. Rüssel fast so lang wie Kopf und Halsschild zusammen, mässig stark gebogen, im basalen Teil mit scharfem Mittelkiel, seitlich desselben matt chagriniert, vorn glänzend, zerstreut punktiert. Stirn mit länglich dreieckigem Eindruck an der Rüsselwurzel. Fühler hinter der Mitte des Rüssels eingelenkt. Schaft- und 1. Geisselglied gleichlang, gut doppelt so lang wie breit; 2. Glied wenig kürzer; 3. bis 5. Glied wiederum etwas kürzer; 6. Glied etwa anderthalbmal so lang wie breit; 7. Glied so lang wie breit. Erstes Glied der Keule wenig länger als breit; 2. Glied kaum so lang wie breit; 3. Glied etwas länger als das 1. Glied. Halsschild wenig länger als breit, seitlich kräftig und gleichmässig gerundet. Skulptur gleichmässig, ziemlich kräftig runzlig; Übergang von Punktierung zur Granulierung, die Erhöhungen sehr dicht chagrinartig punktuliert. Flügeldecken etwa anderthalbmal so lang wie breit, von der Basis bis über die Mitte parallelseitig, dann in gleichmässiger Wölbung zugerundet. Punktstreifen ziemlich fein, linienförmig eingerissen; Zwischenräume viel breiter als die Streifen, mässig stark und sehr dicht, etwas unregelmässig punktiert. Schenkel kräftig; Mittel- und Hintertibien kräftiger als die vorderen, die letzteren leicht gebogen.

Männchen.—Rüssel kürzer, nur so lang wie das Halsschild, weniger gebogen, an der Spitze rot.

Färbung grünmetallisch; Rüssel schwarz; Fühler braun. Behaarung gelblich, kurz, aufgerichtet; auf Mittel- und Hinterbrust lang anliegend, greis, auf dem Abdomen mehr abstehend. Länge, 3 mm.

SINGAPORE (*Baker, 13924; Saunders,* März, 1922). In meiner Sammlung; British Museum (Natural History).

RHYNCHITES SEMIRUGOSUS sp. nov.

Kopf quer, ziemlich fein matt runzlig punktiert. Augen gross, ziemlich kräftig vorgewölbt, etwa doppelt so lang wie die Stirn breit, diese nur wenig schmaler als der Rüssel vor der Basis breit. Rüssel nicht ganz so lang wie Kopf und Halsschild zusammen, schwach gebogen; basaler Teil des Rüssels mit Mittelkiel, von flachen, am Grunde matt chagrinierten Längsfurchen begleitet, vorn längsrunzlig punktiert. Fühler hinter der Rüsselmitte eingelenkt. Schaft- und 1. Geisselglied gleichlang, oval, doppelt so lang wie breit; 2. bis 4. Glied etwas kürzer als das 1. Glied; die restlichen Glieder wieder etwas kürzer als die vorhergehenden. Fühlerkeulenglieder 1 und 2 kaum länger als breit, kräftig; 3. Glied etwas länger. Halsschild so lang wie breit, seitlich kräftig gerundet, die grösste Breite liegt etwas hinter der Mitte, Vorderrand etwas schmaler als die Basis. Mitte des Halsschilds mit feiner Längsfurche; Punktierung in gleicher Stärke wie der Kopf, sehr dicht runzlig. Flügeldecken etwa ein und ein Viertelmal so lang wie breit, parallelseitig; Punktstreifen sehr kräftig, hinten etwas feiner; Zwischenräume vorn schmaler, hinten breiter als die Streifen, fein und sehr dicht unregelmässig punktiert. Pygidium im basalen Teil dichter und hinten etwas weniger gedrängt punktiert. Vordertibien schlank und gerade, Mittel- und Hintertibien kräftiger und gedrungener, die Mitteltibien an der Spitze innen mit kurzem Fortsatz.

Färbung schwarz, Kopf und Halsschild mit leichtem Erzschein, Unterseite mit blauem Schein. Behaarung sehr kurz, geneigt, untermischt mit wenigen kurzen, abstehenden Härchen. Schildchen dicht anliegend greis behaart. Länge 2.5 mm.

MINDANAO, ZAMBOANGA (*Baker, 24394*). In meiner Sammlung.

Dem *R. furvus* m. nahestehend; während jedoch bei dieser Art auch die Flügeldecken matt runzlig punktiert sind, trifft dies auf die vorliegende Art nicht zu: sie sind glänzend und nur einfach punktiert.

RHYNCHITES MOESTUS sp. nov.

Kopf fein und dicht punktiert; auf der Stirn mit tiefer, vorn geöffneter Furche. Augen anderthalbmal so lang wie die Stirn breit, mässig stark vorgewölbt; Kopf über den Augen breiter als der Vorderrand des Halsschilds. Rüssel so lang wie Kopf und Halsschild zusammen, mässig stark gebogen, auf der basalen Hälfte mit feinem Mittelkiel, vorn kräftig und dicht punktiert. Fühler wenig hinter der Rüsselmitte eingelenkt. Schaft- und 1. Geisselglied gleichlang, länglich oval, doppelt so lang wie breit; 2. bis 4. Glied schwächer, kaum kürzer; 5. Glied erheblich kürzer; 6. Glied noch anderthalbmal so lang wie breit; 7. Glied so lang wie breit. Erstes Glied der Fühlerkeule so lang wie breit; 2. Glied breiter als lang; 3. Glied wenig länger als das erste. Halsschild so lang wie breit, schwach konisch, seitlich kaum gerundet; Punktierung mässig stark, sehr dicht runzlig. Flügeldecken fast anderthalbmal so lang wie breit, von den Schultern ab kurz parallelseitig, dann mässig stark gerundet verbreitert. Punktstreifen kräftig; Zwischenräume schräg nach innen abfallend, nach aussen scharfkantig, unregelmässig, dicht verlaufen punktiert. Pygidium wenig deutlich punktiert. Vordertibien schlank, Mittel- und Hintertibien kürz und breit.

Färbung braunschwarz. Behaarung kurz abstehend, mässig dicht. Länge 2.8 mm.

LUZON, Mount Maquiling (*Baker*). In meiner Sammlung.

Unter der grossen Zahl verwandter Arten mit runzlig punktiertem Halsschild steht die vorliegende Art dem *R. cinnamomi* m. von Java sehr nahe.

RHYNCHITES PARVUS sp. nov.

Kopf quer, mässig stark und sehr dicht, besonders im basalen Teil runzlig punktiert. Stirn nur halb so breit wie der Rüssel an der Basis. Augen gross, ziemlich kräftig vorgewölbt, etwa dreimal so lang wie die Stirn breit. Schläfen sehr kurz. Rüssel wenig länger als das Halsschild, schwach gebogen. Basis mit Doppelfurche und Mittelkiel, der sich vor der Fühlereinlenkung gabelt und hinter derselben wieder vereinigt, sich dann nach vorn keilförmig verbreiternd. Fühler wenig hinter der Rüsselmitte eingelenkt. Schaft- und 1. Geisselglied gleichlang, fast doppelt so lang wie breit; 2. Glied wenig kürzer; 3. bis 6. Glied etwas kürzer als das 2. Glied; 7. Glied wiederum nur wenig kürzer als die vorhergehenden Glieder. Keule erheblich länger als die Geissel; die Glieder gleichlang, gut anderthalbmal so lang wie breit. Halsschild fast etwas länger als breit, am Vorderrand wenig schmaler als an der Basis, seitlich schwach gerundet. Punktierung ziemlich kräftig runzlig. Schildchen quer, viereckig. Flügeldecken etwa anderthalbmal so lang wie breit, parallelseitig. Punktstreifen sehr kräftig; Zwischenräume schmal, stumpf kielartig, weitläufig einreihig punktiert. Pygidium an der Spitze breit abgestutzt. Hinterschenkel sehr kräftig. Vordertibien schlank, Mittel- und Hintertibien kräftiger und kürzer.

Färbung schwarz. Behaarung ziemlich kurz, etwas geneigt, untermischt mit länger abstehenden Haaren. Während auf der Hinterbrust mit Seitenteilen die Haare mässig dicht, lang anliegend angeordnet sind, sind das Halsschild, das Abdomen und die Beine lang abstehend behaart. Länge 2.5 mm.

MINDANAO, Zamboanga (*Baker*). In meiner Sammlung.

Eine Art, die an der schmalen Stirn unter den verwandten auffällt und leicht kenntlich ist.

RHYNCHITES SIBUYANENSIS sp. nov.

Weibchen.—Kopf quer, fein und sehr dicht, teilweise runzlig verlaufen punktiert. Augen ziemlich kräftig vorgewölbt, ihr Längsdurchmesser grösser als die Stirn breit und diese etwas breiter als der Rüssel an der Basis dick. Schläfen kurz. Rüssel etwas länger als Kopf und Halsschild zusammen, wenig gebogen, von der Basis schwach zur Mitte verschmälert, zur Spitze etwas mehr verbreitert; im basalen Teil mit feinem Mittelkiel, begleitet von je einer Punktfurche; vorn glänzend, vereinzelt punktiert. Fühler etwas hinter der Mitte eingelenkt. Schaft- und 1. bis 4. Geisselglied gleichlang, das Schaft- und 1. Geisselglied jedoch etwas kräftiger, zusammen länger als der Rüssel an der Fühlereinlenkung dick; 5. bis 7. Glied etwas kürzer. Erstes und 2. Glied der Keule fast anderthalbmal so lang wie breit; 3. Glied etwas länger. Halsschild etwas länger als breit, schwach konisch und leicht gerundet nach vorn verschmälert, fein und sehr dicht runzlig punktiert. Flügeldecken gut anderthalbmal so lang wie breit, parallelseitig. Punktstreifen ziemlich kräftig; Zwischenräume breiter als die Streifen, leicht gewölbt, fein und dicht, etwas unregelmässig punktiert. Pygidium wenig vorstehend. Vordertibien schlank, Mittel- und Hintertibien gedrungen, aussen mit einer fein gekerbten Leiste.

Färbung schwarz; Abdomen, Fühlergeissel, Hüften und Beine (mit Ausnahme der angedunkelten Spitzenpartie der Schenkel) mehr oder weniger rot. Grundbehaarung kurz, aufgerichtet, untermischt mit länger aufstehenden Haaren. Mittel- und Hinterbrust mit Seitenteilen fein und dicht anliegend behaart. Länge 3.2 bis 3.5 mm.

INSEL SIBUYAN (*Baker, 21140, 21144*). In meiner Sammlung; United States National Museum.

Beim Männchen ist der Rüssel wenig länger als das Halsschild.

RHYNCHITES JUVENILIS sp. nov.

Kopf quer, sehr fein vereinzelt punktiert. Augen so lang wie die Stirn breit, ziemlich kräftig vorgewölbt; Schläfen kurz. Stirn etwa anderthalbmal so breit wie der Rüssel an der Fühlereinlenkungsstelle dick. Rüssel erheblich länger als Kopf und Halsschild zusammen, schlank, von der Basis zur Fühlereinlenkung konisch verschmälert; im ganzen gleichmässig schwach gebogen; glänzend und kaum sichtbar punktiert, im basalen Teil mit kurzem Mittelkiel und je einer Begleitfurche. Fühler im basalen Fünftel bis Sechstel der Rüssels eingelenkt, das ist um etwas mehr als Schaftgliedlänge von der Rüsselwurzel entfernt. Schaftglied gestreckt, so lang wie der Rüssel an der Fühlereinlenkungsstelle dick; 1. Geisselglied länglich oval, etwas kürzer als das Schaftglied; 2. Glied so lang wie das Schaftglied; 3. bis 4. Glied erheblich länger, doch nicht ganz so lang wie das Schaft- und 1. Geisselglied zusammen; 5. und 6. Glied noch etwas länger als das Schaftglied; 7. Glied noch doppelt so lang wie breit. Erstes Glied der Keule fast dreimal so lang wie breit; 2. Glied wenig kürzer; 3. Glied so lang wie das 1. Glied, spindelförmig. Halsschild so lang wie breit, seitlich gleichmässig schwach gerundet, am Vorderrand kaum schmaler als an der Basis, vor demselben schwach eingeschnürt; Mittelfurche fein. Punktierung ziemlich fein und wenig dicht. Schildchen quer, viereckig, mit schwachem Grübchen vor der Spitze. Flügeldecken doppelt so lang wie breit, parallelseitig. Punktstreifen kräftig; Zwischenräume so breit wie die Streifen, gewölbt, ziemlich fein, entfernt stehend einreihig punktiert. Pygidium im basalen Teil fein und weitläufig, hinten kräftiger und dichter punktiert. Abdomen sehr fein und zerstreut punktiert. Tibien gerade, mässig schlank, die Hintertibien kräftiger, alle mit schwach gezähntem Aussenkiel. Der verkürzte vorletzte Punktstreif vereinigt sich erst in der Höhe des 1. Abdominalsegments mit dem Randstreif.

Färbung schwarz; Rüssel, Fühler (mit Ausnahme der Keule und der zwei letzten Geisselglieder), Beine und grösstenteils das Abdomen rot; Flügeldecken blau. Behaarung greis, auf den Zwischenräumen der Flügeldecken einreihig gereiht untermischt mit einzelnen abstehenden Härchen; auf dem Halsschild wirr, teilweise mehr abstehend; auf dem Abdomen sparsam, abstehend, an den Seiten der Mittel- und Hinterbrust mit Seitenteilen dicht anliegend; Beine lang abstehend behaart. Länge 3.5 mm.

INSEL BASILAN (*Baker*). Ein Exemplar in meiner Sammlung.

Eine in jeder Hinsicht leicht kenntliche Art, die ihren nächsten Verwandten eigenartigerweise in Westafrika hat.

RHYNCHITES MODESTUS sp. nov.

Kopf mit Augen breiter als lang, ziemlich kräftig und sehr dicht punktiert; Augen gross, mässig stark vorgewölbt, viel länger als die Stirn breit und diese etwas schmaler als der Rüssel vor der Basis dick. Schläfen schwach konisch. Rüssel so lang wie das Halsschild, gleichmässig kräftig gebogen. Basalhälfte mit Mittelkiel, seitlich desselben flach gefurcht und am Grunde dicht punktiert, vorn kräftig und sehr dicht punktiert. Fühler mittenständig. Schaftglied oval, länger als breit; 1. Geisselglied anderthalbmal so lang wie das Schaftglied, länglich oval; 2. bis 4. Glied länger als das 1. Glied; die restlichen Glieder etwa so lang wie das Schaftglied. Erstes und 2. Glied der Fühlerkeule fast doppelt so lang wie breit; 3. Glied breiter als lang, Endglied konisch zugespitzt. Halsschild so lang wie breit, konisch, seitlich leicht gerundet, am Vorderrand viel schmaler als an der Basis, fein und sehr dicht punktiert. Flügeldecken etwa ein und ein Drittelmal so lang wie breit; bis zur Mitte parallelseitig, dann gerundet verschmälert. Punktstreifen mässig kräftig, hinten etwas feiner als im basalen Teil; Zwischenräume fein und sehr dicht unregelmässig punktiert. Abdomen sehr fein und weitläufig punktiert, Pygidium dagegen kräftiger und dicht. Hinterschenkel kräftig; Vordertibien schlank und gerade, Mitteltibien kräftiger und gedrungener.

Färbung schwarz; Flügeldecken und Unterseite mit leichtem bläulichen Schein. Grundbehaarung ziemlich kurz, wenig geneigt, gelblich, untermischt mit einzelnen, länger abstehenden Haaren. Mittel- und Hinterbrust mit Seitenteilen anliegend, Abdomen mehr abstehend behaart. Länge 4 mm.

SINGAPORE (*Baker, 13923*). In meiner Sammlung.

Die Art steht dem *R. liveus* m. von Vorder-Indien am nächsten, die Fühler sind jedoch viel schlanker, die Zwischenräume sind feiner punktiert, die Grundbehaarung ist kürzer, auch ist die Färbung des Tieres dunkler.

RHYNCHITES FIGURATUS sp. nov.

Kopf breiter als lang, kräftig und dicht punktiert. Augen kräftig vorgewölbt, länger als die Stirn breit, Schläfen sehr kurz. Rüssel ziemlich kräftig, so lang wie Kopf und Halsschild zusammen, kräftig gebogen; oben im basalen Drittel mit Mittelfurche und je einer Begleitfurche, im ganzen kräftig und sehr dicht längsrunzlig punktiert. Fühler zwischen der Mitte und dem basalen Drittel eingelenkt. Schaft- und 1. Geisselglied gleichlang, oval, nicht ganz doppelt so lang wie breit; 2. und 3. Glied etwas länger. Halsschild breiter als lang, Vorderrand wenig schmaler als die Basis, vor demselben leicht eingeschnürt, seitlich schwach gerundet, die grösste Breite liegt etwas hinter der Mitte. Punktierung fein, sehr dicht querrunzlig. Schildchen quer viereckig, fein und dicht punktiert. Flügeldecken etwa anderthalbmal so lang wie breit, parallelseitig. Punktstreifen kräftig, hinten etwas feiner; 1. bis 3. Zwischenräume breiter als die Streifen, die seitlichen schmaler, sehr fein und dicht unregelmässig punktiert. Vordertibien schlank, die hinteren kräftig, keilartig zur Spitze verbreitert.

Färbung rotgelb; Seiten des Halsschilds und ein Mittelband, Schildchen, Naht und Seiten der Flügeldecken, vor der Mitte derselben vom 4. Zwischenraum bis zur Naht mit einem + ~ — förmigen Querband und hinter der Mitte mit einem ebenfalls geschwungenen querband, welches durch den 3. Zwischenraum unterbrochen wird, Vorder-, Mittel-, Hinterbrust, die Schenkel mit Ausnahme der Basis, Spitze der Tibien und Tarsen dunkler gebräunt. Behaarung auf den Zwischenräumen der Flügeldecken quer gelagert, greis, anliegend, sonst länger abstehend. Länge 3.2 mm.

MINDANAO, Butuan (*Baker, 4430*); Surigao (*Boettcher* Juli, 1916). In meiner Sammlung, Mus. Berlin (coll. Moser).

Die durch die greise, dichte Behaarung der Zwischenräume verstärkte Zeichnung der Flügeldecken macht diese Art unter den bisher bekannten leicht kenntlich.

RHYNCHITES AZURESCENS sp. nov.

Eine Art, die dem *R. helleri* m. sehr nahe steht und mit diesem leicht verwechselt werden könnte, wenn nicht einige Gegensätze ziemlich scharf ausgeprägt wären: Der auffälligste Unterschied liegt in anderer Kopfform, so sind die Augen wesentlich kleiner und nicht viel länger als die Stirn breit. Der Rüssel, der bei *helleri* in der basalen Hälfte parallelseitig ist, läuft bei unserer Art konisch verjüngt zur Mitte zu. Die beiden ersten Glieder der Fühlerkeule sind etwas schlanker und länger und die Behaarung ist wesentlich sparsamer, sodass die Art tiefer blau gefärbt erscheint. Auch in der Punktierung der Decken liegen geringe Unterscheide.

MINDANAO, Surigao (*Baker, 17108, 17109*). In meiner Sammlung; United States National Museum.

MELASIDÆ ET ELATERIDÆ NOUVEAUX DES ILES PHILIPPINES

Par E. FLEUTIAUX

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MELASIDÆ

FORNAX HADDENI sp. nov.

Longueur 7.5 mm. Allongé, atténué; brun obscur; pubescence jaune. Tête convexe, densément ponctuée; crête interoculaire interrompue au milieu; épistome notablement rétréci en arrière, moins large à la base que l'espace surantennaire. Antennes brunes, filiformes, dépassant légèrement la base du prothorax; 2e article très petit; 3e long; 4e un peu plus court. Pronotum aussi long que large à la base, subgraduellement rétréci en avant, peu convexe, densément ponctué. Elytres atténués dès la base, terminés en pointe, finement pointillés, très légèrement substriés. Dessous de même couleur, finement et densément ponctué. Sillons antennaires étroits, nettement rebordés en dedans, lisses et brillants. Pointe prosternale arrondie au sommet. Abdomen faiblement comprimé; dernier arceau ventral en pointe obtuse. Pattes brunes.

LUZON, Laguna, Pangil, mai (*F. C. Hadden*).

Voisin de *F. dircæoides* Fleutiaux. Pronotum graduellement rétréci de la base au sommet; élytres atténués dès la base. Diffère de *F. subacuminatus* Bonvouloir par le pronotum graduellement rétréci, par la ponctuation des élytres plus légère, par le dernier arceau ventral en pointe obtuse.

FORNAX SEMINIGER Fleutiaux var. NIGRICEPS nov.

Fornax seminiger FLEUTIAUX, Ann. Soc. Ent. France (1926) 46, 48. (Subgen. *Spinifornax* Fleutiaux.)

Tête noire.

LUZON, Laguna, Pangil, avril (*F. C. Hadden*).

ELATERIDÆ

MELANOXANTHUS HADDENI sp. nov.

Longueur 8 mm. Allongé, peu convexe; noir, pronotum rouge sur presque toute sa surface en arrière; élytres ornés chacun d'une large bande jaune pâle médiane à la base, prolongée jusqu'à la moitié et d'une tache ronde de même couleur avant l'extrémité; pubescence peu apparente, de la couleur du fond. Tête peu convexe, arrondie en avant, densément ponctuée. Antennes noires, comprimées, ne dépassant pas la base du prothorax. Pronotum brillant, plus long que large, parallèle, brusquement arrondi aux angles antérieurs, peu convexe; ponctuation très fine et peu serrée; angles postérieurs aigus, non divergents, bicarénés. Elytres subparallèles, rétrécis dans le dernier tiers, tronqués au sommet, peu convexes, densément ponctués, striés-ponctués. Dessous finement et densément ponctué; pubescence jaune légère; propectus jaune clair; métasternum et abdomen noirs. Pattes jaune clair.

LUZON, Laguna, Mont Maquiling, mai (*F. C. Hadden*).

Ressemble à *M. exclamationis* Candèze; moins convexe, plus brillant; taches des élytres jaune pàle; sommet des élytres tronqué; pourtour du pronotum en avant el latéralement noir; dessous de l'arrière-corps noir.

MELANOXANTHUS FINITIMUS sp. nov.

Longueur 6 mm. Allongé, subparallèle, peu convexe; dessus jaune, tête écusson et sommet des élytres noirs, brillant; pubescence fine, peu apparente, de la couleur du fond. Tête convexe, ponctuation peu serrée. Antennes noires, comprimées et faiblement élargies vers le bout; 3e article semblable et presque aussi long que le suivant. Pronotum un peu plus long que large, paralléle, arrondi aux angles antérieurs; ponctuation moins forte que sur la tête, peu serrée; angles postérieurs aigus, non divergents, brièvement carénés. Elytres ponctués-striés; interstries plans et finement pointillés. Propectus jaune, pointe prosternale noire; reste du dessous noir, très finement ponctué. Pattes noirâtres; trochanters jaunes.

LUZON, Laguna, Mont Maquiling, janvier (*F. C. Hadden*).

Ressemble à *M. dimidiatipennis* Candèze; tête non carénée au milieu; antennes entièrement noires; pronotum paralléle; élytres moins rugueux, noirs seulement au sommet sur le cinquième postérieur; dessous de l'arrière-corps noir; pattes noirâtres.

MELANOXANTHUS LATERALIS sp. nov.

Longueur 4 mm. Allongé, noir, angles du pronotum jaune pâle, élytres testacés avec la suture noire; pubescence jaune clairsemée. Tête convexe; ponctuation assez forte, irrégulièrement espacée. Antennes brunes, plus claires à la base, ne dépassant pas la base du prothorax. Pronotum plus long que large, faiblement rétréci en avant, convexe; ponctuation assez large, peu profonde, irrégulièrement espacée; angles postérieurs grands, aigus, insensiblement divergents, carénés. Elytres convexes, arrondis latéralement et rétrécis en arrière, entiers au sommet, fortement ponctués-striés; ponctuation des interstries espacée. Dessous et pattes noirs.

LUZON, Baguio, 5,000 pieds, mars (*F. C. Hadden*).

Voisin de *M. fusus* Candèze; plus allongé; élytres de la même largeur que le pronotum, moins fortement ponctués-striés; bords externes largement testacés; pattes noires.

MEGAPENTHES CINCTUS sp. nov.

Longueur 9 mm. Oblong, assez large, peu convexe; noir avec la base du pronotum et le pourtour des élytres jaune brillant; pubescence obscure, rousse sur les parties jaunes. Tête peu convexe, densément ponctuée. Antennes courtes, ferrugineuses; 3e article de même forme, mais notablement moins long que le suivant. Pronotum un peu plus long que large, parallèle, arrondi aux angles antérieurs, convexe, brusquement déclive à la base, impressionné le long du bord postérieur, très légèrement sillonné au milieu en arrière, assez densément ponctué; angles postérieurs courts, non divergents, unicarénés. Elytres arrondis et rétrécis seulement dans le dernier tiers, légèrement ponctués-striés, presque indistinctement au sommet; interstries plans, finement et espacément pointillés; bande jaune entourant les élytres assez large occupant la base, rétrécie sur le bord externe au delà de la moitié. Dessous noir, bord latéral des propleures jaune; pubescence brune. Pattes testacées.

LUZON, Laguna, Mont Maquiling, 400 pieds, juin (*F. C. Hadden*).

Voisin de *M. curtus* Candèze; front non caréné au milieu; élytres de même largeur que le pronotum, stries plus légères.

MONOCREPIDIUS HADDENI sp. nov.

Longueur 8.5 mm. Oblong, ellipsoidal, peu convexe; noir peu brillant; pubescence fauve légère, plus sombre sur la tête et le pronotum. Tête plate, impressionnée au milieu en arrière, densément ponctuée; palpes testacé pâle. Antennes fines, n'atteignant pas la base du prothorax, testacées, noirâtres vers le milieu. Pronotum plus long que large, arrondi sur les côtés, peu rétréci en avant, brusquement déclive à la base, faiblement et brièvement sillonné en arrière, finement et densément ponctué; angles postérieurs courts, non divergents, carénés. Elytres arrondis latéralement et graduellement atténués, fortement striés-ponctués; interstries plans sur le dos, convexes sur les côtés, densément ponctués. Dessous noir; pubescence fauve, finement et densément ponctuée, surtout sur l'abdomen. Hanches postérieures anguleuses. Pattes testacé pâle.

LUZON, Laguna (*F. C. Hadden*).

De même forme que le *M. horistonatus* Candèze; de couleur noire.

NEODIPLOCONUS NIGRIPES sp. nov.

Longueur 11 mm. Allongé, atténué en avant et en arrière; noir, pronotum rouge sanguin, sauf sur le bord antérieur et à l'extrémité des angles postérieurs; pubescence grise. Tête peu convexe, déprimée en avant; bord antérieur arrondi et rebordé; ponctuation peu serrée. Antennes noires, dépassant la base du prothorax; 3e article légèrement plus long que le 2e; 4e égal aux deux précédents réunis. Pronotum plus long que large, graduellement et notablement rétréci en avant, peu convexe, sillonné au milieu en arrière; ponctuation plus apparente en avant et sur les côtés, extrêmement fine et très écartée sur le dos, nulle à la base; angles postérieurs aigus, divergents, bicarénés. Elytres graduellement rétrécis, conjointement arrondis au sommet, peu convexes, très légèrement ponctués-striés, presque lisses. Dessous et pattes noires.

LUZON, Mountain Province, Mont Data, 5,000 pieds, mars; Baguio, 5,000 pieds, mars; Laguna, Mont Maquiling, mai (*F. C. Hadden*).

Moins brillant que *N. haddeni* Fleutiaux; ponctuation de la tête moins forte; pronotum graduellement rétréci, non arrondi sur les côtés; angles postérieurs divergents; élytres presque lisses; dessous et pattes noires.

NEODIPLOCONUS COXALIS sp. nov.

Longueur 9.5 mm. Allongé, parallèle; noir brillant; pubescence jaune peu abondante. Tête déprimée, arrondie et rebordée en avant; ponctuation forte, peu profonde, rugueuse. Antennes brunes, courtes. Pronotum plus long que large, parallèle, arrondi aux angles antérieurs, brièvement sillonné au milieu en arrière et à la base; ponctuation assez forte, peu serrée, moins marquée en arrière; angles postérieurs légèrement divergents, aigus bicarénés. Elytres de la même largeur que le pronotum, parallèles, arrondis dans le dernier quart, entiers au sommet; ponctués-striés, interstries plans et finement pointillés. Dessous ferrugineux, propleures noirs. Propectus assez fortement ponctué; arrière-corps plus légèrement. Hanches postérieures graduellement rétrécies en dehors. Pattes ferrugineuses.

LUZON, Laguna, Mont Maquiling, 400 pieds, juin; Laguna, Pangil, mai; Tayabas, Quezon Park, mai (*F. C. Hadden*).

Voisin de *N. cantharus* Candèze; plus étroit, plus parallèle; noir; ponctuation plus distincte; hanches postérieures non anguleuses.

NEODIPLOCONUS FUSCUS sp. nov.

Longueur 10.5 mm. Allongé, atténué, peu convexe; noir; pubescence jaune peu abondante. Tête convexe, arrondie en avant; ponctuation forte, peu profonde peu serrée. Antennes brunes, ne dépassant pas la base du prothorax. Pronotum plus long que large, sinué sur les côtés, rétréci en avant, impressionné à la base; ponctuation assez forte, peu serrée, effacée à la base; angles postérieurs aigus, non divergents, bicarénés. Elytres de même largeur que le pronotum, arrondis latéralement et rétrécis en arrière, entiers au sommet, légèrement ponctués-striés; interstries pointillés. Dessous ferrugineux. Pattes plus claires.

LUZON, Laguna, Mont Maquiling, 400 pieds, juin (*F. C. Hadden*).

Moins parallele que *N. coxalis* m.; antennes plus longues; ponctuation de la tête et du pronotum moins forte; interstries des élytres légèrement convexes.

NEUE BRENTHIDÆ UND LYCIDÆ VON DEN PHILIPPINEN

Von R. Kleine
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EINE TAFEL

Genus MACROPAREIA novum

Von robuster Gestalt. Kopf länger als breit, durch das mit demselben verbundene Meta- und Mesorostrum stark verlängert erscheinend; Hinterrand tief, dreieckig eingebuchtet und in eine tiefe Mittelfurche verlängert, die sich auf dem Metarostrum noch mehr vertieft; Oberseite abgeplattet, Wangen gross, platt; Unterseite platt mit einer bis zum Rüssel durchgehenden Mittelfurche; Augen nach vorn gerückt, mittelgross. Metarostrum mit dem Kopf in einer Ebene liegend; Mesorostrum unentwickelt, schmal, tief gefurcht; Prorostrum kurz, am Vorderrand so breit wie der Kopf, daselbst tief eingebuchtet; Mandibeln kräftig. Fühler nach vorn in tiefen Gruben eingesenkt, robust, 2. bis 8. Glied breiter als lang, basale Glieder mehr rundlich, die vorderen mit kantigem Vorderrand, 9. und 10. nicht breiter als das 8., aber länger und fast quadratisch, 11. so lang wie das 9. und 10. zusammen. Prothorax gegen den Hals stark verengt, ungefurcht. Zweite Rippe auf den Elytren in der Mitte weit unterbrochen, die übrigen Rippen mehr oder weniger breit, platt, zum Teil breiter als die Furchen. Beine robust, Vorderschiene mit Zahnartigem Haarbüschel, Schienen der Hinterbeine im Verhältnis zur Länge sehr breit, Metatarsus länger als das 2. und 3. Glied zusammen, seitlich stark zusammengepresst.

Typus der Gattung: *M. schultzei* sp. nov.

In meiner Bestimmungstabelle der Brenthidæ komme ich zur Gattung *Orthopareia* Kleine, die auch nur auf den Philippinen vorkommt. Eine gewisse Verwandtschaft damit ist sicher vorhanden. So ist beiden Gattungen die unterbrochene 2. Rippe auf den Elytren gemeinsam, ausserdem ist der Rüssel von ähnlicher Gestalt. Die Unterschiede sind folgende:

Orthopareia.	*Macropareia.*
Kopf breiter als lang, Hinterrand gerade, gewölbt, ungefurcht.	Kopf länger als breit, durch die Tiefe über den ganzen Kopf reichende Furche fast in zwei Teile zerlegt.
Metarostrum schmaler als der Kopf, Mesorostrum erweitert.	Metarostrum von Kopfbreite, Mesorostrum ganz schmal.
Fühler lang, Glieder quadratisch oder länger als breit.	Fühler kurz, mit Ausnahme des 11. sind alle Glieder breiter als lang.
Prothorax gegen den Hals nicht verengt, tief gefurcht.	Prothorax stark verengt, ungefurcht.

MACROPAREIA SCHULTZEI sp. nov.

Hell schokoladebraun, Halsschildrand, Vorderrand der Fühlerglieder, Schenkel und Schienen an Basis und Spitze schwarz, am ganzen Körper hochglänzend. Kopf einzeln punktiert, Rüssel, namentlich das Prorostrum, sehr dicht und tief punktiert. Fühler auffallend schwach behaart, selbst das 9. bis 11. Glied sind nur mit ganz geringem Haarwuchs bedeckt. Prothorax, Metasternum, Abdomen, und die Beine mit derselben Skulptur versehen.

Länge, 13 mm., Breite, (Prot.) 1.75 mm.

PANAY, Antique, Culasi (*W. Schultze*).

Typus in dessen Sammlung.

LYCIDÆ

CALOCHROMUS LUZONICUS sp. nov.

Unterseite des Körpers, Kopf, Beine und Fühler blauschwarz, mit Ausnahme der Fühler stark glänzend; Prothorax, Schildchen und Elytren mit Ausnahme eines grauschwarzen keilförmigen Fleckes im Spitzenteil schmutzig bleichgelb, die dunkle Partie mit undeutlichen hellen Rippen, die auch ganz fehlen können. Kopf dicht punktiert und behaart mit deutlicher Mittelfurche, Mandibulartaster mit beilförmigem Endglied. Fühler schlank, 1. bis 4. Glied Abb. 4, die folgenden von gleicher Länge, nach und nach schmaler werdend. Prothorax Abb. 5, Mittelfurche im vorderen Drittel fehlend, sonst sehr tief. Schildchen lippenförmig. Elytren mit sehr kurzer Behaarung, sodass die Rippen, auch die sekundären, deutlich erkennbar sind. Schenkel ungedornt.

Länge, 13 bis 14 mm., Breite, (Hum.) 3 mm.

LUZON, Benguet, Baguio, 2 Männchen.

Typus in der Sammlung Schultze, Cotype in meiner Sammlung.

Die Art ist durch die Ausfärbung mit keiner anderen in der ganzen Gattung zu verwechseln. Auf den Philippinen ist die helle Elytrenfarbe namentlich in der Gattung *Plateros* häufig, bei *Calochromus* aber bisher gänzlich unbekannt. Ausserdem is die Anlage der Elytrenverdunklung ganz apart. Bemerkenswert ist auch das Zusammentreffen der stahlblauen Körperunterseite mit der schmutziggelben Oberseite.

LIBNETIS SPINICORNIS sp. nov.

Gleicht in Ausfärbung und Habitus *decolor* Kleine durchaus. Durch die an der Spitze innenseits gedornten Fühlerglieder sicher und leicht zu unterscheiden.

Länge, 4 mm., Breite, (Hum.) 1 mm. circa.

MINDANAO, Bukidnon, Tangkulan (*C. F. Baker*), 1 Männchen.

Typus in meiner Sammlung.

PLATEROS ZONATUS sp. nov.

Schwarzbraun, Prothorax an den Seitenrändern breiter, am Vorderrand nur ganz schmal und die Elytren in der vorderen Hälfte bleichgelb. Stirn flach, rundlich vertieft, Fühlerbeulen schwach entwickelt, glänzend. Fühler robust, 1. bis 4. Glied Abb. 8, die folgenden von gleicher Länge, aber nach und nach schmaler werdend, ohne Zähnung; Behaarung dicht und kräftig, ausser der Unterbehaarung mit einzelnen langen abstehenden Haaren besetzt. Prothorax etwas breiter als hoch, Hinterecken vorgezogen. (Abb. 9). Vorder- und Seitenrand erhöht, Randpunktierung kräftig, Behaarung sehr gering. Schildchen zungenförmig, am Hinterrand kaum eingebuchtet. Elytren mit kurzer dichter Behaarung, die nur die Primärrippen erkennen lässt. Die beiden Farbenkomplexe sind scharflinig getrennt. Penis Abb. 10.

Länge, 8 mm., Breite, (Hum.) 1.5 mm. circa.

LUZON, Benguet, Santo Tomas. Männchen und Weibchen.

Holotypus in Sammlung Schultze; Allotypus in meiner Sammlung.

Es handelt sich um eine grosse Art aus der Verwandtschaft von *cuneatus* und *ponderosus*. Die Trennung ist aber durch den Penis sehr leicht und sicher, da das Organ *fulgidus* ähnlich ist, nicht aber den genannten Arten. Mit *fulgidus* besteht hingegen keinerlei Uebereinstimmung, schon durch die Ausfärbung nicht.

PLATEROS PUDENS sp. nov.

Abdomen schwarzbraun, Brust gelb, Beine braun mit hellgelber Schenkelbasis, Kopf orangegelb, Fühler schwarz, die ersten beiden Glieder gelbbraun, Prothorax, Schildchen und Elytren strohgelb. Die Stirn anderthalbmal so breit wie ein Augenhalbmesser, über den flachen Fühlerbeulen mit zwei punktartigen Vertiefungen, Behaarung sehr gering. Erstes bis sechstes Fühlerglied Abb. 12, nach vorn nehmen die Glieder an Breite und Länge ab, 9. und 10. Glied ohne Zähnung, 11. länger als das 10., kräftig behaart. Prothorax Abb. 13, breiter als lang, Vorderecken stumpf, Seiten hinter der Mitte nach innen gebogen, Hinterecken deutlich vorgezogen, alle Ränder erhöht, Randpunktierung gross, einzeln, Behaarung schwach. Schildchen zungenförmig, hinten nicht eingekerbt, kurz behaart. Elytren mit sehr deutlichen Rippen und ebensolcher Gitterung, die durch die kurze Behaarung nicht verdeckt wird; Gitterung vier- bis fünfeckig.

Länge, 6.5 mm., Breite, (Hum.) 1.25 mm.

MINDANAO, Zamboanga (*C. F. Baker*), 1 Weibchen.

Typus in meiner Sammlung.

Pudens ist mit *luteolus* Kleine und *generalis* Kleine zu vergleichen. Von ersterer Art unterscheidet sie sich sehr leicht durch den queren Prothorax, von *generalis* durch die hellgefärbte Brust und die zweifarbigen Schenkel.

PLATEROS PAULULUS sp. nov.

Einfarbig schwarz, nur der Prothorax mit schmutzig-orangeroten Seitenrändern. Stirn doppelt so breit wie ein Augenhalbmesser, über den Fühlerbeulen flach eingesenkt, diese mit deutlicher Mittelrinne. Erstes bis fünftes Fühlerglied Abb. 13, nach vorn nehmen die Fühlerglieder an Breite, nicht aber an Länge ab, 11. Glied wenig länger als das 10., Behaarung kurz und einzeln. Prothorax Abb. 14, Vorderecken gerundet, Hinterecken nicht vorgezogen, Seiten fast gerade, Ränder mässig aufgebogen, Randpunktierung kräftig, Behaarung einzeln. Schildchen zungenförmig, nicht eingekerbt. Auf den Elytren sind Rippen und Gitterung zwar nur sehr flach ausgebildet, werden aber durch die sehr kurze und einzelne Behaarung nicht verdeckt. Gitterung vier bis fünfeckig. Penis Abb. 15.

Länge, 6.5 mm., Breite, (Hum.) 1.5 mm.

LUZON, Mt. Banahao, 1 Männchen.

Typus in meiner Sammlung.

Von den in der Ausfärbung sehr ähnlichen *triangulus* Kleine, *simillimus* Kleine, *contrarius* Kleine und *contextus* Kleine durch den gänzlich anders gebauten Penis leicht zu unterscheiden.

PLATEROS EXIGUUS sp. nov.

Abdomen schwarz, Brust gelb, Beine mit Ausnahme der gelben Schenkelbasis schwarz, Kopf und Fühler von derselben Farbe, Prothorax und Schildchen orangegelb, Elytren im vorderen Drittel von derselben Farbe, sonst schwarz. Stirn nur so breit wie ein Augenhalbmesser, über den flachen Fühlerbeulen schwach vertieft. Fühler wie bei *pudens*. Prothorax so breit wie in der Mitte hoch, Vorderecken mehr oder weniger gerundet, Hinterecken spitz vorgezogen, Ränder aufgebogen, Randpunktierung gross, einzeln, Behaarung sehr gering, Abb. 16. Schildchen zungenförmig, Hinterrand fast gerade, Behaarung sehr gering, Elytren mit sehr deutlichen Rippen und gleicher Gitterung, Behaarung sehr gering, die Skulptur nicht verdeckend, Gitterung vorherrschend fünfeckig, seltener viereckig.

Länge, 4 bis 6 mm., Breite, (Hum.) 1 bis 1.25 mm.

MINDANAO, Zamboanga; Insel Basilan (*C. F. Baker*), 3 Männchen.

Typus in meiner Sammlung.

Von allen bisher bekannten Arten besteht die grösste Aehnlichkeit mit *constans* Kleine. Der Penis ist von ähnlicher Gestalt, aber die Fühler sind in beiden Arten ganz verschieden. Während bei *exiguus* das 3. und die folgenden Glieder kräftig gezähnt sind, fehlt die Zähnung bei *constans* vollständig und die Glieder liegen schmal dicht einander an. Die Trennung der beiden Arten ist auch ohne Penisautopsie leicht. Die Identität der einzelnen Stücke war nur durch Penisvergleich möglich.

LEPTOTRICHALUS PERVERSUS sp. nov.

Abdomen, Brust und Beine blau metallisch, glänzend, Kopf und Fühler schwach, Prothorax, Schildchen und das basale Drittel der Elytren hell strohgelb, hintere zwei Drittel schwarzbraun. Kopf über den Fühlerbeulen vertieft, Fühler schlank 8. bis 11. Glied Abb. 19. Prothorax mit stark aufgebogenen Seitenrändern und schwacher Randpunktierung, Areole nur am Hinterrand offen. Schildchen hinten tief eingekerbt. Elytrengitterung vorherrschend quer rechteckig, in der hinteren Hälfte zum Teil ohne deutliche Figuren, Behaarung kurz.

Länge, 17 mm., Breite, (Hum.) 4 mm.

LUZON (*Boettcher*), 1 Weibchen.

Typus in meiner Sammlung.

Die Art unterscheidet sich von allen bisher bekannten sehr leicht durch die Ausfärbung und ist nur mit der nächstfolgenden zu vergleichen.

LEPTOTRICHALUS PLACITUS sp. nov.

Grauschwarz, Prothorax mit mehr oder weniger gelbgrauen Rändern, Schildchen gelbgrau, Elytren im basalen Teil von gleicher Ausfärbung, die ohne scharfen Absatz in die graue Farbe übergeht. Prothorax wie bei der vorigen Art, Ränder weniger scharf aufgebogen. Fühler sehr schlank, 8. bis 11. Glied Abb. 20. Schildchen hinten nicht eingekerbt. Elytrengitterung unscharf, vier- bis fünfeckig.

Länge, 13 mm., Briete, (Hum.) 3 mm.

LUZON, Baguio (*C. F. Baker*), 2 Weibchen.

Typus in meiner Sammlung.

Die Ausfärbung ist der vorigen Art recht ähnlich, ist aber, wie an den vorliegenden Exemplaren zu sehen ist, etwas wechselnd. Auf den Elytren kann die graue Farbe bis zur Basis vordringen, lässt dann aber immer noch die Seitenränder frei. *Placitus* ist viel schlanker als *perversus*, die Fühler sind von ganz anderer Gestalt und das Schildchen ist nicht eingebuchtet.

LEPTOTRICHALUS RELIQUUS sp. nov.

Abdomen graubraun, Brust und Beine gelblich braun, die Schenkel noch weiter aufgehellt, Kopf schwarzbraun, Rüssel und Fühler rotbraun, Prothorax strohgelb mit braunlicher Areole, Schildchen und das basale Fünftel der Elytren strohgelb, allmählich in graubraune Farbe übergehend. Fühler wie bei *perversus*. Areole des Prothorax an beiden Seiten geschlossen, Ränder nur schwach aufgebogen. Schildchen deutlich eingebuchtet. Elytrengitterung namentlich im vorderen Teil unregelmässig Abb. 21.

Länge, 8.5 mm., Breite, (Hum.) 1.75 mm. circa.

LUZON (*Boettcher*), 1 Männchen.

Typus in meiner Sammlung.

Die Art unterscheidet sich von den beiden vorhergehenden abgesehen von der Ausfärbung vor allen Dingen durch die ganz verschiedene Elytrengitterung. Auch an den Teilen des Organes, wo die Skulptur nicht unterbrochen ist, sind die Gitterungsfiguren nicht quadratisch oder regular fünfeckig, sondern immer auffallend lang.

LEPTOTRICHALUS INCERTUS sp. nov.

Schwarzbraun, nur die Elytren im basalen Viertel hellgelb. Fühler sehr schlank, ähnlich wie *placitus*. Prothorax mit auffallend nach aussen vorgezogenen spitzen Hinterecken, Areole hinten offen. Schildchen nur ganz wenig eingebuchtet. Elytrengitterung sehr unregelmässig Abb. 21, Behaarung fehlt fast ganz.

Länge, 8 mm., Breite, (Hum.) 1.5 mm.

LUZON (*Boettcher*), 1 Männchen.

Typus in meiner Sammlung.

Von den drei vorhergehenden Arten unterscheidet sich *incertus* sehr leicht durch die ganz andere Ausfärbung. Während bei den vorhergehenden Arten der Prothorax entweder ganz oder doch wenigstens zum Teil gelb gefärbt ist, ist er bei *incertus* schwarz. Die dunklen Farbentöne sind überhaupt tiefer als bei den anderen Arten. Dazu kommt noch, dass der Prothorax durch die vorgezogenen Hinterecken von den der anderen Arten ganz abweicht. Die Elytren, die bei *reliquus* nur im basalen Teil unregelmässig skulptiert sind, haben bei *incertus* nur im spitzen Teil im geringen Umfange reguläre fünfeckige Figuren.

ILLUSTRATION

TAFEL 1

ABB. 1 bis 3. *Macropareia schultzei* sp. nov.; *1*, Kopf; *2*, Fühler; *3*, Tibia und Tarsen der Hinterbeine.

4 bis 6. *Calochromus luzonicus* sp. nov.; *4*, 1. bis 4. Fühlerglied; *5*, Prothorax; *6*, Habitusbild der Ausfarbung.

7. *Libnetis spinicornis* sp. nov.; mittlere Fühlerglieder.

8 bis 11. *Plateros zonatus* sp. nov.; *8*, 1. bis 4. Fühlerglied; *9*, Prothorax; *10*, Penis; *11*, Habitusbild der Ausfarbung.

12 und 13. *Plateros pudens* sp. nov.; *12*, 1. bis 6. Fühlerglied; *13*, Prothorax.

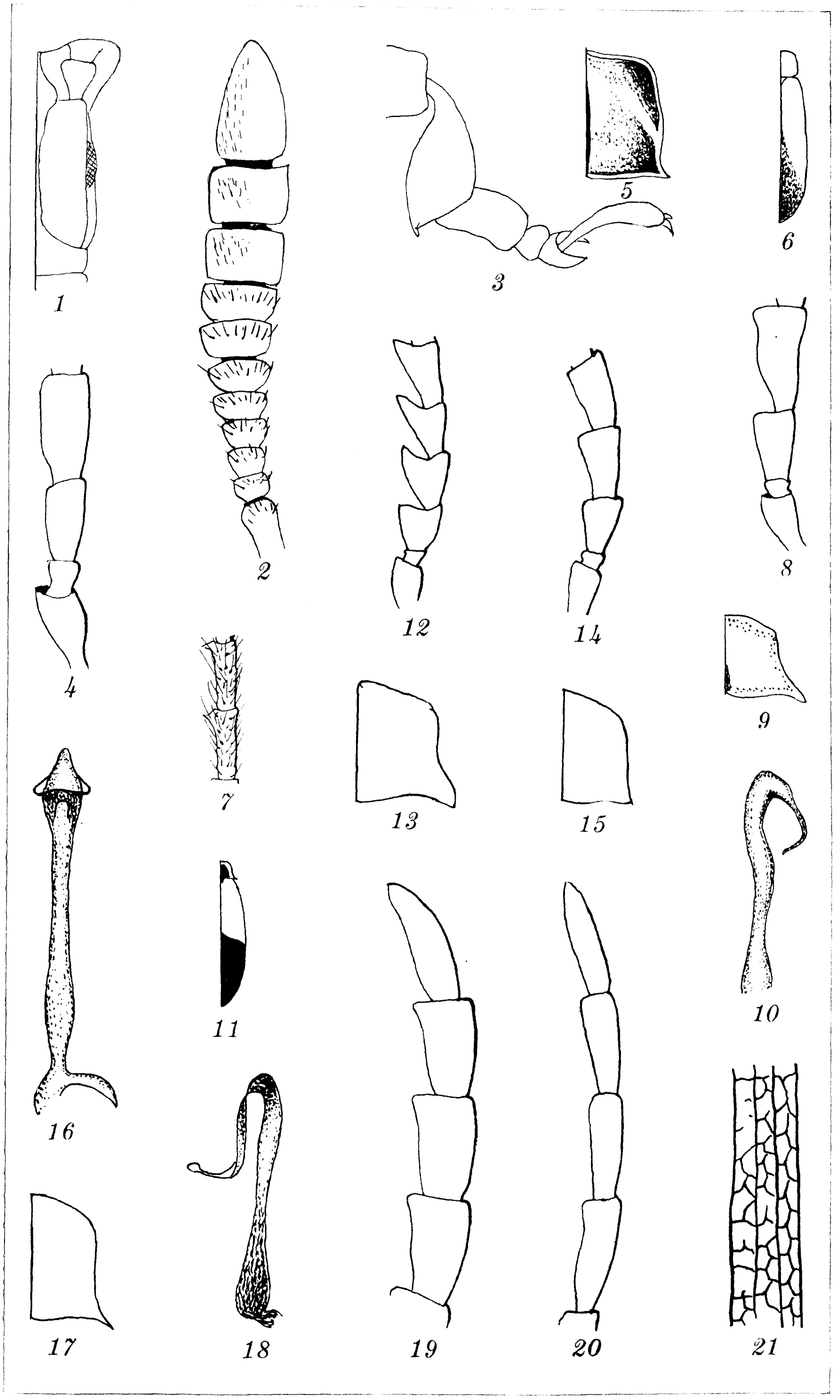
14 bis 16. *Plateros paululus* sp. nov.; *14*, 1. bis 5. Fühlerglied; *15*, Prothorax; *16*, Penis.

17 und 18. *Plateros exiguus* sp. nov.; *17*, Prothorax; *18*, Penis.

19. *Leptotrichalus perversus* sp. nov.; 8. bis 11. Fühlerglied.

20. *Leptotrichalus placitus* sp. nov.; 8. bis 11. Fühlerglied.

21. *Leptotrichalus reliquus* sp. nov. und *L. incertus* sp. nov.; Elytrengitterung.



TAFEL 1.

DETERMINATION OF ORGANIC MATTER IN ACCUMULATOR SULPHURIC ACID SOLUTIONS

By ROLLIN G. MYERS

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Recently Craig[1] has described a method for the determination of small quantities of formic, acetic, and other volatile organic acids in the sulphuric acid solutions used in lead accumulators. These acids are quite undesirable, especially the acetic acid, because of the corrosive action on the positive plates of the cell. In addition to the acids mentioned, there are also small quantities of organic matter present in the accumulator sulphuric acid. The presence of this organic matter is also objectionable and accordingly only traces are permitted.

Experiments recorded in this paper were carried out with the idea of ascertaining some method suitable for the routine analysis of organic matter in accumulator sulphuric acid solutions. A review of the literature indicates that there is no standard method for this determination.

The presence of organic matter in the sulphuric acid electrolyte of lead accumulators originates from the thin layers of "treated wood separator" placed between the anode plates of the cell. Since the wood is in immediate contact with the electrolyte and for a considerable length of time, hydrolytic changes appear to take place with the formation of substances which are probably decomposition products of cellulose.

However, it is probable that these changes may be modified to a considerable extent through the influence of the electric current passing to and from the cell during cycling. Moreover, it is quite likely that oxidation processes may also take place accompanied by the formation of organic acids such as formic and acetic. According to Craig these acids are actually found in cycled electrolytes.

Perhaps these acids are split off directly by the action of sulphuric acid on the wood cellulose or are formed later through a breaking down of hydrolyzed cellulose products, like biose or monose. The second supposition, however, seems to merit the greater weight particularly in view of the possible oxidation processes that take place in the cell. Accepting this view as the more probable, any cause tending to increase the organic matter in the electrolyte would also tend to increase the quantities of objectionable acetic and other organic acids. In view of this possibility the determination of the amount of organic matter in the electrolyte has considerable practical importance.

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[1] Bur. Standards Journ. Research 6 (1931) 169.

EXPERIMENTAL PROCEDURE

In working out a method for the determination of organic matter in accumulator sulphuric acid solutions it was first thought that a colorimetric method could be developed from the procedure used as a qualitative test for organic matter in the electrolyte. This consists in evaporating a portion of the electrolyte until the fumes of sulphur trioxide appear. If organic matter is present a brown shade develops due, of course, to the charring of the carbonaceous substances in solution. The depth of the brown shade developed naturally depends on the amount of organic matter in solution. Experiments were carried out by evaporating equal weights of standard glucose-sulphuric acid solutions and the electrolyte solution to a maximum color shade. Color comparisons were then made by matching the color shade of equal volumes of the electrolyte with a series of standard glucose solutions ranging from 0.10 to 0.001 per cent. The results were unsatisfactory as the color shades developed in the electrolyte often varied considerably from those of the standard glucose solutions. The development of maximum color shade was also difficult to obtain because if evaporation was continued too long a decided bleaching of the color occurred. Again it was difficult to prevent the precipitation of carbon from its colloidal solution.

The uncertainties noted in the colorimetric method gave added weight to the necessity of determining the organic matter by some gravimetric method in which the experimental conditions could be more accurately controlled. Obviously the separation of the excess sulphuric acid in the electrolyte would seem to be the first step. For this purpose barium carbonate seemed to be an appropriate reagent. However, experiments showed that the barium carbonate separation was not suitable for various reasons. First, the inconveniently large amounts of insoluble barium sulphate and excess carbonate obtained during the separation of the sulphate radical made it difficult to remove all the organic matter occluded in the precipitate even after several extractions. Again even the "analyzed" barium carbonate used was found to contain appreciable quantities of organic matter. Finally, a series of test determinations made on the same electrolyte showed a considerable variation in the amounts of organic matter found even when the procedure was most carefully carried out.

The difficulties of the barium carbonate separation suggested the use of neutral lead acetate solution as a better means of eliminating the sulphate radical. The lead acetate separation, which proved to be the most successful, was carried out in the following manner: A portion of the electrolyte (about 7 grams) was weighed into a 200-cubic-centimeter Erlenmeyer flask and enough alcohol was added to make the volume of the solution, after the lead sulphate precipitation, consist of about 50 per cent alcohol. The solution was heated to the boiling point and neutral lead acetate solution (25 grams in 100 cubic centimeters of water) was added gradually from a burette until there was a slight excess. If the solution is allowed to boil gently and is agitated vigorously the sulphate radical is precipitated easily and completely. The insoluble sulphate settles out rapidly leaving a clear supernatant solution. After precipitation, the flask containing the insoluble lead sulphate was stoppered loosely, placed in an inclined position, and allowed to cool. The supernatant solution was then decanted into a beaker and the precipitated lead sulphate washed into a centrifuge tube with dilute alcohol (50 per cent). After centrifuging about five minutes the clear solution was poured from the compact lead sulphate into the beaker containing the supernatant solution previously obtained. To insure the elimination of all but traces of organic matter the lead sulphate was again washed with dilute alcohol, centrifuged, and the washings added to the solutions previously separated from the lead sulphate. The combined solutions were then evaporated to a volume of about 30 cubic centimeters. About 0.5 cubic centimeter of glacial acetic acid was added, the solution was heated to the boiling point, and a rapid stream of hydrogen sulphide gas was passed into the hot solution. After digesting on a steam bath for a few minutes the lead sulphide was removed by filtering. The filtrate was boiled to volatilize the excess hydrogen sulphide and then evaporated to dryness.

To purify the residue it was treated with about 3 cubic centimeters of boiling water. Sufficient barium hydroxide solution was then added to remove the slight amount of iron originally contained in the electrolyte. The mixture was then stirred thoroughly, digested for a few minutes on a steam bath, filtered into a weighed platinum dish, and evaporated to dryness. The residue was then heated to constant weight, at a temperature of about 105° C., after which it was ignited at a low red heat until all the carbon was removed.

In order to check the organic matter that might be contained in the reagents used or introduced during the analysis corresponding blank determinations were carried out using Merck's reagent sulphuric acid which had a specific gravity of 1.198 at $\frac{30^\circ}{30^\circ}$ C. The amount of organic matter found in the blank analyses varied from 0.022 to 0.026 per cent.

Seven typical accumulator electrolytes of various ages were analyzed by the lead acetate method. This method apparently has various advantages. No objectionable voluminous precipitates are obtained as in the barium carbonate separation. Again the excess lead can be easily removed by hydrogen sulphide. Finally, the remaining by-products, acetic acid with some ethyl acetate, present no special difficulty since both compounds can be readily and completely volatilized leaving the desired organic matter in the residue.

Table 1 summarizes the data obtained in these experiments.

SUMMARY

A method for the determination of organic matter in accumulator sulphuric acid solutions has been worked out. This method depends on the use of lead acetate for the removal of excess acid in the electrolyte.

Six electrolytes varying in age from one to five years and one unused electrolyte were analyzed.

Considering the small amount of organic matter contained in the electrolyte and the difficulties of separating it the individual analysis for each sample (Table 1) gave results which agreed fairly well except in the case of sample 2.

The corrected percentage of organic matter found in accumulator sulphuric acid solutions varies from 0.075 to 0.088 per

cent (Table 1). A new solution which had not been used gave 0.003 per cent organic matter.

Apparently, the organic matter does not increase with long continued service. In fact, a solution that was used one year contained even slightly more organic matter than one used for five years.

TABLE 1.—*Organic matter in accumulator sulphuric acid solutions.*

Sample No.	Age of electrolyte.	Analysis No.	Weight of purified residue.[a]	Organic matter.		Sulphuric acid by weight.	Sulphuric acid, specific gravity $\frac{30^\circ}{30^\circ}$ C.
				Obtained in each analysis.	Average results corrected for blank.[b]		
	Years.		*g.*	*Per cent.*	*Per cent.*	*Per cent.*	
1	4.5	1	0.0028	0.109		25.62	1.1930
		2	0.0026	0.093	0.078		
2	4.5	1	0.0024	0.072		27.72	1.2010
		2	0.0025	0.111			
		3	0.0036	0.149			
		4	0.0028	0.112			
		5	0.0020	0.084	0.083		
3	5	1	0.0020	0.093		25.88	1.1872
		2	0.0021	0.092			
		3	0.0020	0.106			
		4	0.0022	0.103	0.075		
4	2	1	0.0027	0.102		25.52	1.1995
		2	0.0020	0.100			
		3	0.0026	0.105	0.079		
5	2.5	1	0.0024	0.110		11.19	1.0748
		2	0.0025	0.112	0.088		
6	1	1	0.0029	0.109		27.36	1.1973
		2	0.0024	0.089			
		3	0.0025	0.096			
		4	0.0031	0.121	0.081		
7	([c])	1	0.0006	0.026	0.003	23.40	1.1698

[a] Residue (before ignition) from 1 gram of electrolyte.

[b] Organic matter found in the blank analysis varied from 0.022 to 0.026 per cent.

[c] Fresh sample not yet used.

COMPOSITION OF SOME PHILIPPINE HARDWOODS, IV[1]

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and
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Of the Bureau of Science, Manila

FOUR PLATES

For industries which use wood as their basic raw material the composition of woods is a matter of considerable importance. We have been working several years on the composition of Philippine woods. Three papers have already appeared,[2] and this one makes our fourth report which includes some of the Philippine hardwoods. An account of the general properties of these woods is given by Schneider.[3] Brief descriptions are as follows:

Kayatau (*Dysoxylum turczaninowii* C. DC.) belongs in a genus which has about twenty-five tree species in the Philippines. These different species are widely distributed but always scattered. Kayatau is a straight tree of medium height and grows to a maximum diameter of about 80 centimeters. The wood is hard and moderately heavy with a texture that is fine, dense, and smooth. When fresh the wood has an odor suggesting that of sandal wood. The durability is at least 2, and even the sapwood is rarely attacked by beetles. The wood is useful for posts and general construction work. On account of its beauty of texture, color, and insect-proof qualities it is very suitable for fine cabinet work and beautiful moth-proof chests.

Lago [*Pygeum vulgare* (Koehne) Merr.] is a tree which sometimes reaches a diameter of 60 centimeters. The wood is moderately hard and heavy and is rarely attacked by beetles.

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[1] This work is carried on coöperatively by the division of organic chemistry, Bureau of Science, and the Bureau of Forestry.

[2] Yenko, F. M., Luz Baens, A. P. West, and H. M. Curran, Philip. Journ. Sci. **47** (1932) 281 and 343; **48** (1932) 299.

[3] Bull. P. I. Bur. Forestry **14** (1916).

The wood seasons well and is easy to work. The durability is about 3. It is used for posts and general construction work. It is also employed for making picture frames and is a substantial wood for cabinet work.

Lamóg (*Planchonia spectabilis* Merr.) is a tall straight tree which sometimes grows to a diameter of more than 100 centimeters. The wood is hard and moderately heavy with a texture which is rather fine and smooth. It has a durability of 2, is fairly easy to work, and is rarely attacked by insects. It is used for posts and general construction work and makes a beautiful cabinet wood. This species is widely distributed in Luzon and the Visayan islands but is scattered.

Binggas [*Terminalia comintana* (Blanco) Merr.] is a tall, fairly straight tree which may reach a diameter of 100 centimeters or more. The wood is hard and heavy and has a durability of at least 3. The texture is fine and smooth. The wood seasons well and works smoothly, and even the sapwood is not attacked by beetles. It is used for posts, general construction work, furniture, and cabinet work.

Bolon [*Alphonsea arborea* (Blanco) Merr.] is a large forest tree reaching a diameter of from 70 to 80 centimeters with an upright, straight, and regular trunk; crown close and branches more or less horizontal; stem darkish in color; bark very thick and contains bast fibers. The wood is of medium quality as to weight and hardness and is used for light construction and cabinet work. It is not durable in contact with the ground. This species occurs in abundance at low and medium altitudes in central and southern Luzon, Mindoro, Visayan Islands, and Mindanao.

Kariskis [*Albizzia lebbekoides* (DC.) Benth.] is a small to medium-sized tree which may have a diameter of about 40 centimeters. The wood is hard and moderately heavy. It has a durability of 1 and is practically never attacked by beetles. It is used for posts and general construction work, interior finish, furniture, and cabinet work. It is widely distributed but scarce.

Bayanti (*Aglaia llanosiana* C. DC.) belongs to a genus which has about fifty species in the Philippines. These different species are widely distributed but do not grow to a very large size. Bayanti grows to a diameter of about 35 centimeters. The wood is very hard, heavy, and dense. It is one of the finest woods of this genus with a fine and dense texture. It seasons well and has an aromatic odor which is somewhat pungent.

The durability is at least 2. The heartwood is rarely, if ever, attacked by termites or the sapwood by beetles. In localities where this wood occurs it is a favorite for house posts and agricultural implements on account of its strength and durability. It is also very suitable for fine furniture, cabinet work, and moth-proof chests.

Bayok (*Pterospermum diversifolium* Blume) and kulatiñgan (*Pterospermum obliquum* Blanco) are members of a genus which has about seven species in the Philippines. These two species are widely distributed and large enough to furnish saw lumber. Bayok grows to a diameter of about 50 centimeters and kulatiñgan to about 70 centimeters. The wood of these trees is rather hard, tough, and moderately heavy to heavy. The texture is fine and smooth. The wood is used for posts, general construction work, and furniture. Probably good ties and paving blocks could be made from the wood if impregnated.

Next to the lauans the narra family contains the most important timber trees in the Islands, producing a much greater variety of hard, durable, and beautifully colored cabinet woods than any other family. Narra (*Pterocarpus indicus* Willd.) is the most familiar member of this family. The wood of narra is moderately hard to hard and moderately heavy. Of all the common Philippine woods the heartwood of narra is the most variable in color, ranging from pale straw through shades of pink, salmon, and deep red to dull brown. Commercially, narra is classified as "red," "yellow," or "white," but individual specimens may have most any color from light to brown. Narra has a rather fine texture, seasons well, shrinks and checks but little, and hardly warps at all. It is easy to work, has a durability of 2, and is rarely attacked even by termites.

Narra is the most widely known high-grade interior finish, furniture, and cabinet wood in the Philippines and is used for numerous purposes. Most of the single-piece round table tops are made from the buttress roots of narra.

In Table 1 are given the measurements of the trees from which samples were taken for our analyses.

In analyzing the wood samples we followed, in general, the methods adopted by the forest products laboratory at Madison, Wisconsin.[4] Certain details in the analytical procedures [5] which we found by previous experience to increase the accuracy of the results were introduced.

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[4] Bray, M. W., Paper Trade Journ. 87 No. 25 (1928) 59.—Schorger, A. W., Chemistry of Cellulose and Wood (1926) 505.

[5] Yenko, F. M., Luz Baens, A. P. West, and H. M. Curran, Philip. Journ. Sci. 47 (1932) 343.

TABLE 1.—*Measurements of trees used for wood analyses.*

Name of tree.	Diameter.	Total height.	Clear length of trunk.	Height from which specimen was taken.	Specific gravity of wood.
	cm.	*m.*	*m.*	*m.*	
Kayatau; *Dysoxylum turczaninowii*	25	16	12	1.92	0.857
Lago; *Pygeum vulgare*	27	21.5	13.8	2.48	0.753
Lamog; *Planchonia spectabilis*	33	17.1	0.6	2.84	0.872
Binggas; *Terminalia comintana*	28	22	10	2.23	0.906
Bolon; *Alphonsea arborea*	25	21	12	2.12	0.810
Kariskis; *Albizzia lebbekoides*	18	10	3	1.85	0.639
Bayanti; *Aglaia llanosiana*	24	14	5	2.22	1.003
Bayok; *Pterospermum diversifolium*	27	14	5	2.04	0.547
Kulatiñgan; *Pterospermum obliquum*	19	[a] 6.4	6.4	2.08	0.547
Narra; *Pterocarpus indicus*	18	15	5.6	2.25	0.407

[a] The top of this tree was broken.

RESULTS

The results of analyzing the woods recorded in this paper are given in Table 2.

TABLE 2.—*Analyses of Philippine hardwoods.*

[The percentages were calculated on a moisture-free basis.]

Constituent.	Kayatau; *Dysoxylum turczaninowii.*	Lago; *Pygeum vulgare.*	Lamog; *Planchonia spectabilis.*	Binggas; *Terminalia comintana.*	Bolon; *Alphonsea arborea.*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cold-water soluble	2.10	1.84	4.59	3.60	2.02
Hot-water soluble	5.22	3.20	9.32	6.54	4.75
Alkali soluble	5.82	16.43	19.95	16.35	13.14
Ether extract	0.69	2.41	1.47	0.24	0.91
Alcohol extract	1.15	1.60	6.38	4.69	2.95
Ash	1.60	0.20	0.44	1.80	0.71
Nitrogen	0.24	0.25	0.30	0.31	0.77
Lignin	35.16	32.84	39.50	35.32	29.97
Cellulose	52.77	52.14	49.57	47.32	52.26
Ash in cellulose	0.66	0.23	0.34	0.28	0.24
Ash-free cellulose	52.11	51.91	49.23	47.04	52.02
Alpha cellulose in total cellulose	77.02	78.49	75.33	75.87	79.14
Alpha cellulose in the wood	40.64	40.92	37.34	35.90	41.36

TABLE 2.—*Analyses of Philippine hardwoods*—Continued.

Constituent.	Kariskis; *Albizzia lebbekoides.*	Bayanti; *Aglaia llanosiana*	Bayok; *Pterospermum diversifolium.*	Kulatiñgan; *Pterospermum obliquum.*	Narra; *Pterocarpus indicus.*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cold-water soluble	1.97	1.48	5.38	1.81	4.68
Hot-water soluble	6.12	3.73	6.44	3.64	9.55
Alkali soluble	14.13	9.62	15.11	12.99	16.92
Ether extract	1.12	0.73	0.70	0.89	0.69
Alcohol extract	5.14	1.92	7.36	3.95	4.18
Ash	0.19	1.34	1.20	0.64	1.05
Nitrogen	0.42	0.27	0.44	0.50	0.55
Lignin	29.28	31.85	36.81	35.05	31.98
Cellulose	53.98	49.21	50.76	54.85	51.21
Ash in cellulose	0.18	0.20	0.29	0.37	0.29
Ash-free cellulose	53.80	49.01	50.47	54.48	50.92
Alpha cellulose in total cellulose	78.90	74.93	75.64	80.11	80.06
Alpha cellulose in the wood	42.59	36.87	38.39	43.94	41.00

TABLE 3.—*Variation in the principal constituents of some Philippine and American hardwoods.*

Kind of wood.	Cellulose.	Lignin.	Alpha cellulose.	
			In wood.	In total cellulose.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Philippine	47.32–54.85	29.28–39.50	35.90–43.94	74.93–80.11
American [a]	48.68–59.40	21.87–32.74	22.67–43.93	42.45–77.38

[a] Data for American woods were taken from analyses of white ash, pignut hickory, yellow birch, white oak, tanbark oak, and shellbark hickory, Ritter, G. J., and L. C. Fleck, Journ. Ind. Eng. Chem. 14 (1922) 1050, and 15 (1923) 1055.

SUMMARY

Ten samples of wood from Philippine hardwood trees were analyzed in this investigation. These woods have the common names kayatau, lago, lamog, binggas, bolon, kariskis, bayanti, bayok, kulatiñgan, and narra.

As shown by the data (Table 2) the kulatiñgan wood has the highest content of cellulose and alpha cellulose. Lamog has the highest lignin and binggas the highest ash content.

The data given in Table 3 show the variation in the principal constituents of the Philippine woods as compared with some American hardwoods. In general, the Philippine woods appear to be more uniform in composition than the American woods.

The Philippine woods have somewhat less total cellulose than the American woods but considerably more lignin and alpha cellulose.

ILLUSTRATIONS

PLATE 1

Kariskis; ***Albizzia lebbekoides*** **(DC.) Benth.**

PLATE 2

FIG. 1. **Binggas;** ***Terminalia comintana*** **(Blco.) Merr.**
2. Kayatau; *Dysoxylum turczaninowii* C. DC.

PLATE 3

FIG. 1. Bayok; *Pterospermum diversifolium* Blm.
2. Lamog; *Planchonia spectabilis* Merr.
3. Narra; *Pterocarpus indicus* Willd.

PLATE 4

FIG. 1. Lago; *Pygeum vulgare* (Koehne) Merr.
2. Bayanti; *Aglaia llanosiana* C. DC.
3. Kulatiñgan; *Pterospermum obliquum* Blco.
4. Bolon; *Alphonsea arborea* (Blco.) Merr.

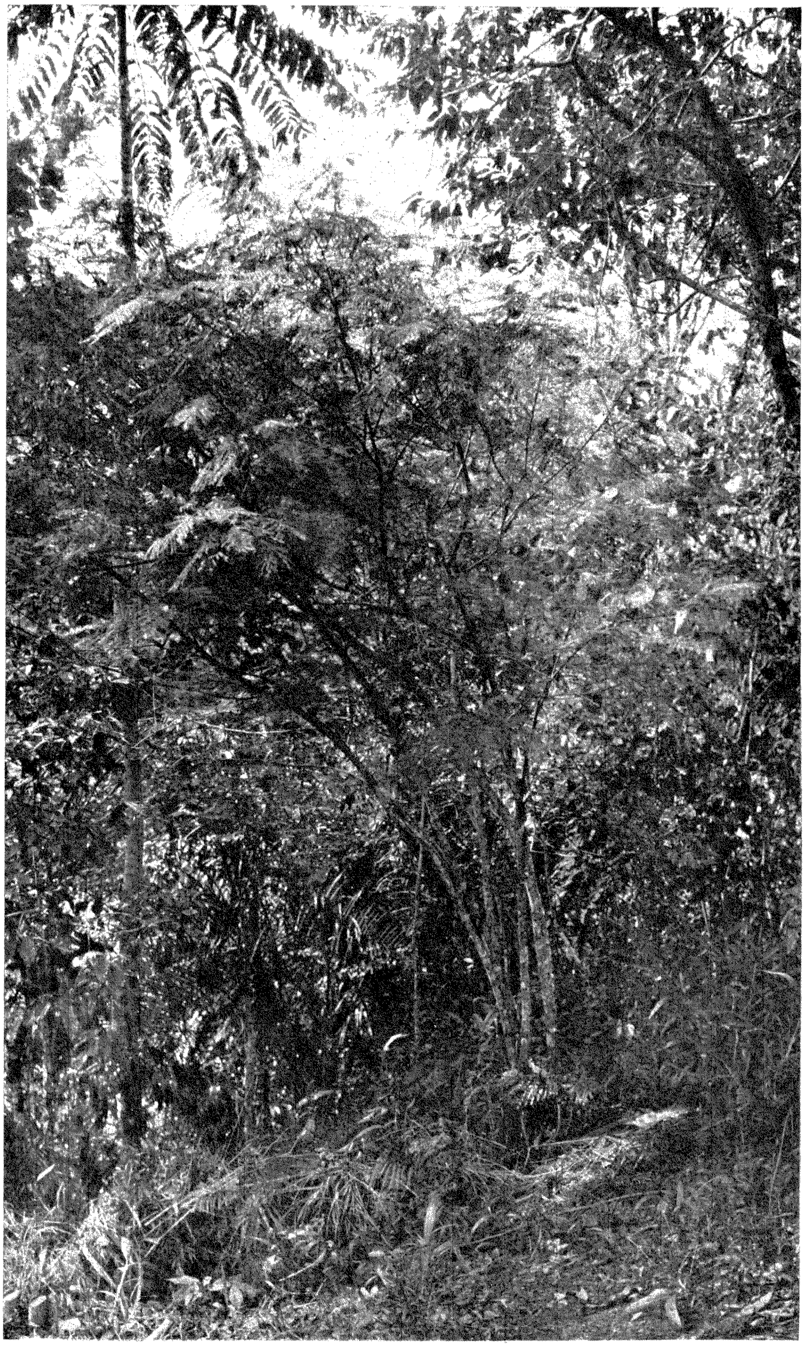

PLATE 1.

UNIV. OF MICH.

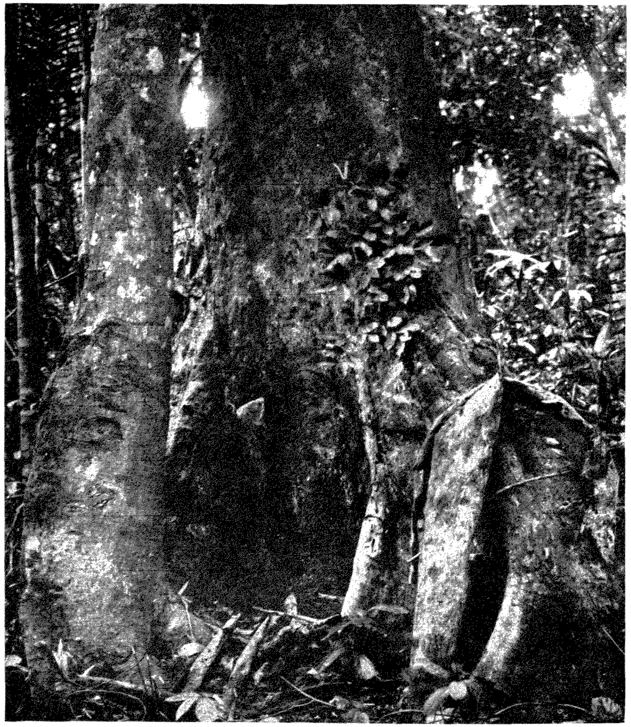

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PLATE 2.

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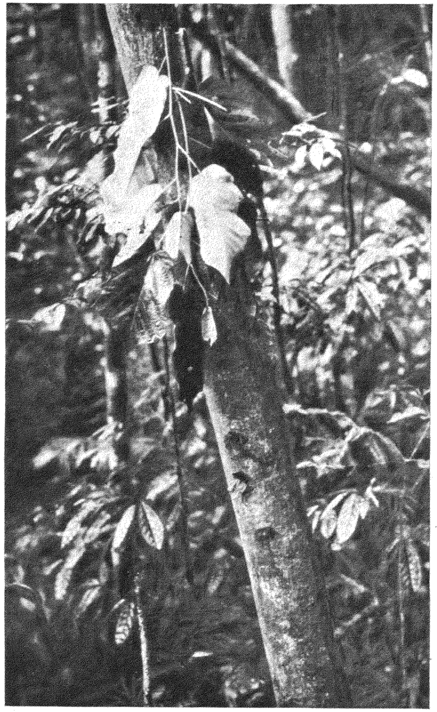

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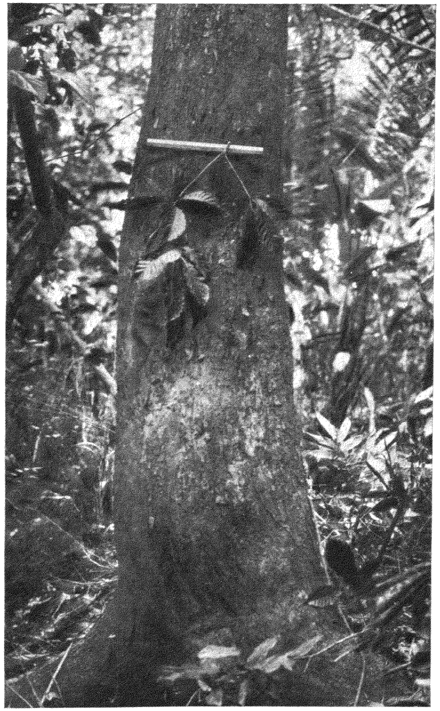

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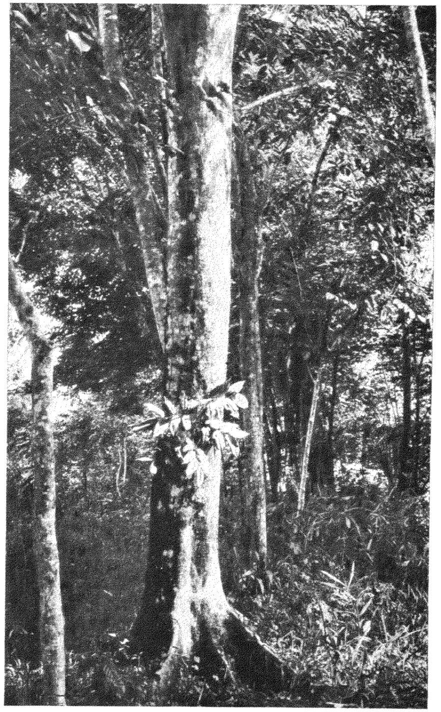

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PLATE 3.

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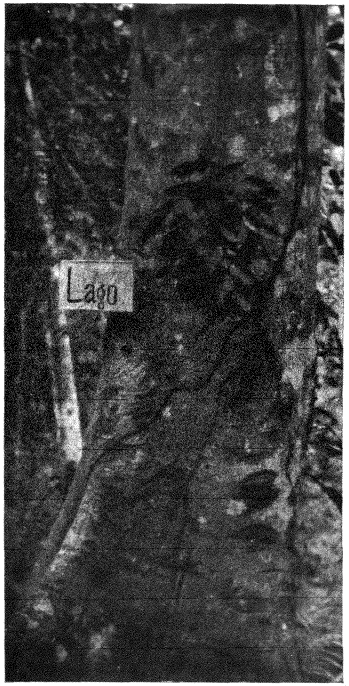

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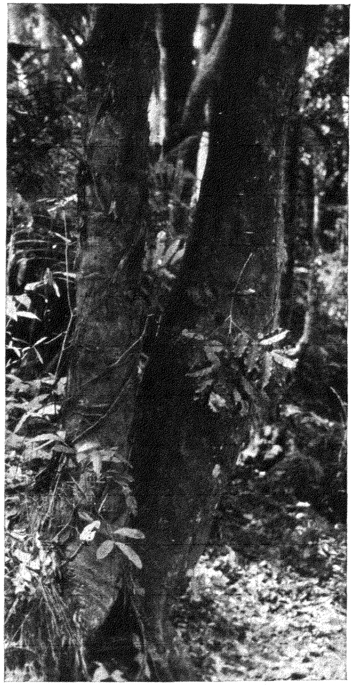

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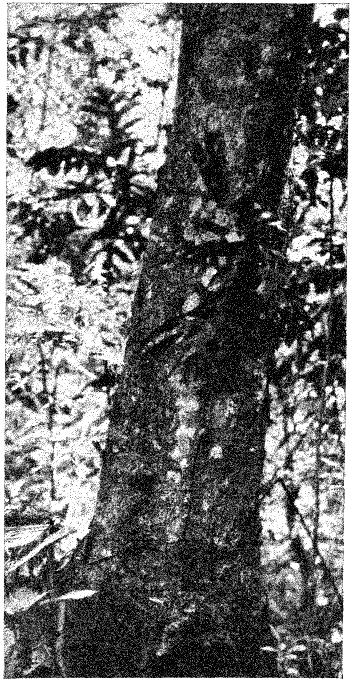

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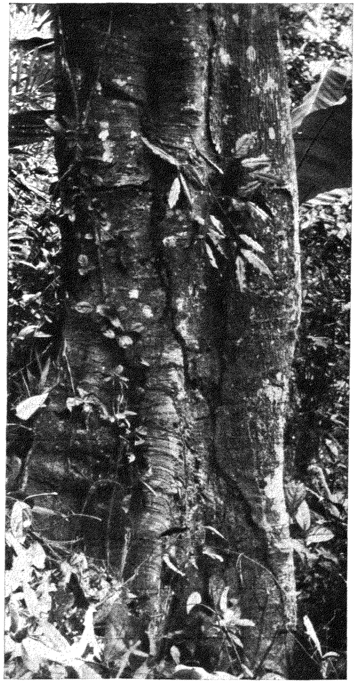

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PLATE 4.

UNIV. OF MICH.

AVIAN MALARIA STUDIES, VII

PLASMOCHIN AS A PROPHYLACTIC DRUG IN SPOROZOITE INFECTIONS OF AVIAN MALARIA [1]

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ONE PLATE

INTRODUCTION

In previous papers (1, 2, 3, 4, 5) one of us has reported some experiments with plasmochin simplex in avian malaria, where attempts at transmitting the disease by blood-saline inoculations of *Plasmodium cathemerium* (Hartman, 1927) from infected birds were invariably prevented by intramuscular injections of as little as 0.00016 gram of this drug in daily doses, provided that the last dose was given subsequent to the infective inoculum. These experiments were successful and although they did not concern sporozoites and were done on birds instead of men yet, naturally enough, led us to further investigations into the possibilities of plasmochin as a prophylactic drug in human malaria and against sporozoite infections in avian malaria.

Not many experiments with plasmochin as a prophylactic in human malaria have been recorded. Fischer (6) gave the drug in doses of 0.059 gram on three consecutive days each week to thirty-seven members of a crew on a steamship sailing from Hamburg to West African river ports. Six cases occurred in spite of this attempt at prophylaxis, but the rate of 15 per cent seemed favorable when contrasted with rate of 25 to 30 per cent among the crews of two steamers following the same route on which quinine was used instead of plasmochin to prevent malaria. As reported in one of our experiments(4) plasmochin has a transient effect, not over five hours. Therefore, the men in Fischer's experiments were left unprotected at least four-sevenths of the time.

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[1] These studies are from the laboratory of malaria investigations, of which the senior author is chief, and which is a project jointly supported by the Bureau of Science, Manila, and the International Health Division of the Rockefeller Foundation. Misses J. M. Ejercito and E. Foronda, microscopists of malaria investigations, assisted in the examination of blood smears. We are indebted to the Winthrop Chemical Company, Dr. G. Schwab, local manager, for the plasmochin simplex and the chinoplasmin used in these experiments.

Ejercito,(7) in the Philippines, gave daily doses of 0.01 gram prophylactic plasmochin with 0.125 gram quinine sulphate to eight individuals and 10 grains of prophylactic quinine sulphate to eight others. Two of the first group and six of the second acquired malaria during eight weeks test.

James, Nicol, and Shute(8, 9, 10) in a small series of controlled experiments with relatively large amounts of plasmochin simplex (the manufacturers have assured us that this is the drug referred to in their work at first as beprochin and later as plasmoquine) found that they could prevent mosquito-borne malarial infections among a group of healthy individuals who took 0.02 gram of the drug on the day before infection and the same dose three times a day thereafter for six days; that is, 0.06 gram on the day of infection and on each of the next five days. These observers stated in their conclusion that they knew from previous tests that "somewhat smaller doses taken over a shorter period are equally effective." What those doses and periods were is not stated.

Swellengrebel and Buck(11) reported a series of experiments along the lines of those by James et al.(9) but using plasmochin in doses which can be tolerated in practice in the field. These authors(11) in their first series gave 0.03 gram of plasmochin simplex daily for six days. On the first day nine plasmochin and three control cases were infected with malaria, each by the bites of at least four rather heavily infected *Anopheles maculipennis* mosquitoes. All were successfully infected and the only effect of the plasmochin was perhaps to shorten the periods of incubation. In a second series they followed the same general procedure but used less heavily infected mosquitoes. Here the plasmochin seemed to prolong the incubation period very slightly and was successful in protecting one out of four cases. The other three and the control became infected.

Swellengrebel and Buck(11) in a third experiment gave one case 0.9 gram of quinine and 0.03 gram of plasmochin daily. Exposure to the bites of several heavily infected mosquitoes resulted in malaria in spite of the quinine and plasmochin.

Recently Russell and Holt(12) reported a field experiment in the Philippines in which it was shown that daily doses of 0.01 gram plasmochin and 0.3 gram quinine sulphate in the form of tablets of chinoplasmin were not always sufficient to prevent the appearance of malaria parasites in the blood, although these doses would occasionally do so and usually forestalled clinical symptoms. Even daily doses of 0.02 gram plasmochin and 0.6 gram quinine sulphate permitted the occasional development of malaria parasites in the blood. Unfortunately, it begins to appear that optimism is to some extent premature and that further search will be necessary to find the practical chemoprophylactic for malaria. Plasmochin is apparently not lethal for sporozoites to the degree it has been shown to be for older asexual forms and for gametocytes. What has been achieved thus far(3, 4, 9) is probably successful early therapy rather than true prophylaxis.

WHAT IS PROPHYLAXIS?

However, it is perhaps quibbling to attempt to analyze such results, as to whether they represent therapy or prevention, for there are no authorized definitions whereby one may make such a separation between early cure and true prophylaxis.

The New English Dictionary,(13) for example, defines "prophylaxis" when used medically as "the preventive treatment of disease." The word "disease" is defined as "a condition of the body, or some part or organ of the body, in which its functions are disturbed or deranged; a morbid physical condition." It also quotes the Sydenham Society Lexicon definition of disease as "a departure from the state of health, especially when caused by structural change."

Webster's(14) dictionary defines "prophylaxis" as the "art of guarding against, preserving from, or preventing, disease; protective, preservative, or preventive treatment."

Gould's(15) medical dictionary defines "prophylaxis" simply as the "prevention of disease; measures preventing the development or spread of disease."

Dorland(16) defines "prophylaxis" as "the prevention of disease. Preventive treatment." The word "disease" is defined as "Any departure from a state of health."

Where among such quotations does one find aid in separating by definition the following hypothetical examples of "prophylaxis"?

(1) Plasmochin applied to the skin repels an infective mosquito and thus is a prophylactic against malaria.

(2) Plasmochin circulating in the blood stream destroys sporozoites immediately after their injection into a capillary by a mosquito and is thus a prophylactic against malaria.

(3) Plasmochin has no effect on the sporozoites but is lethal for the merozoites. The sporozoites undergo full development in the red cells so that there is multiplication of parasites but when the red cell carriers break down the plasmochin destroys the liberated merozoites and thus is a malaria prophylactic.

(4) Plasmochin affects only the gametocytes. They are destroyed or made nonviable. Thus, mosquito infection being impossible, there can be no spread of malaria and plasmochin is a prophylactic against malaria.

(5) Plasmochin sprayed in the air or on water destroys adult or larval mosquitoes and is thus a malaria prophylactic.

It is obvious that, by definition, in the hypothetical case 1 plasmochin is a true prophylactic since there can be no question that it is "a preventive treatment of disease." Case 5 may also be admitted as true prophylaxis although it is not a "treatment" of disease.

Furthermore, case 2 may also be classed as true prophylaxis for the mere injection of sporozoites into the capillaries can scarcely be considered as having caused a state of disease, in that the functions of the body have been deranged only to an infinitesimal degree.

But what of case 3? Is this early treatment or true prophylaxis? Objective but not subjective disease exists and has not been prevented by the plasmochin. Destruction of red blood cells is proceeding. The treatment, therefore, is not preventive but curative, although the patient may not be aware that he has been diseased.

In case 4 there is neither preventive nor curative treatment yet there is "prophylaxis," in a commonly accepted use of the term, because a human malaria carrier having had acute disease and come to a chronic stage, is made noninfective to mosquitoes and thus other cases of malaria are prevented.

Perhaps some day there will be terms to differentiate one type of prophylaxis from another. At present one must assume that any substance or device which in any way, directly or indirectly, prevents subjective disease is in that case a prophylactic of that disease—defining disease as "any departure from a state of health." This is too broad a definition and in practice is often arbitrarily restricted. Quinine in sufficient doses will cure malaria and thus prevent the spread of this disease to others. If taken continuously it will keep a company of troops, for example, relatively free of symptoms even in highly malarious places, subjective disease appearing only after the men have returned to their nonmalarious base and stopped taking quinine. But the present tendency among malariologists is to refuse the term "prophylactic" to quinine in reference to malaria. In spite of its superiority over quinine as regards its lethal effects on gametocytes it seems doubtful if plasmochin will have much better claim to the title "prophylactic."

The following experiments in avian malaria are in line with the disappointing results in human malaria of Swellengrebel and Buck(11) in the laboratory, and Russell and Holt(12) in the field.

GENERAL PROCEDURE

It is not necessary to describe our general procedure as regards technic of blood inoculations, blood-smear examinations, and the administration of plasmochin. We followed that described fully in previous papers.(3, 4) In those reports were also discussed the usual course of infection and the test of susceptibility in birds which remain negative after attempted infection.

MOSQUITO TECHNIC

All of the mosquitoes used in these experiments were of the species *Culex quinquefasciatus* (*fatigans*). In every case the adults used were reared from larvæ, usually obtained from egg rafts laid in laboratory cages but occasionally from larvæ collected in the field.

Mosquitoes to be infected were put into cages 12 by 12 by 20 inches in size, having wooden frames and suitable cloth netting. Gametocyte-carrying birds were tied in small wire cages 5 by 5 by 5 inches in size. These small bird cages were placed inside the mosquito cage and allowed to remain there usually for one night, sometimes longer (see Plate 1). Mosquitoes showing evidence of a blood meal were segregated in similar cloth cages and kept quiet while sporozoites developed.

The technic of infecting birds was the same, except that in this case the mosquitoes were infected and the birds susceptible.

We had no difficulty in raising adult *Culex* mosquitoes and none in keeping these alive for periods of a month or more.

PLASMODIUM CATHEMERIUM

In the first thirty-eight experiments, from June 12 to September 22, 1931, inclusive, we used the strain of *Plasmodium cathemerium* (Hartman, 1927) that has been used in other experiments in our laboratory.(3, 4, 17, 18) As noted elsewhere(17) the susceptibility of *Culex quinquefasciatus* for *P. cathemerium* as regards oöcysts was 48 per cent in 1930 in our experiments.

In the present series of experiments the infecting power of this *Plasmodium* in *Culex quinquefasciatus* has been low. Of eighty-eight birds, which for one to five nights were exposed, in experiments 1 to 38, to the bites of *Culex quinquefasciatus* mosquitoes, previously fed on gametocyte-carrying birds, only two became infected. Susceptibility was proved in forty-six of the birds, and twenty-nine more were examined frequently for at least two weeks after exposure. Eleven died before the result of the experiment could be known. In other words, since there is no reason to suppose any of the birds were not susceptible, two birds in seventy-seven became infected, an infection rate of 2.6 per cent. The fact that approximately half of the birds in this series had plasmochin makes little difference in the interpretation of these figures since there is no evidence that the drug prevented infection. In fact, the two positive cases each received plasmochin. See Table 1.

PLASMODIUM CAPISTRANI

In experiments 39 to 93, October 12, 1931, to April 9, 1932, we used *Plasmodium capistrani* Russell, 1932.(18) As noted below, in some of the experiments infection was attempted by bites of infected mosquitoes and in others by the injection of saline-sporozoite mixtures. The general results of these experiments with *P. capistrani* are summarized in Table 2. It will be seen that of the two hundred thirteen birds used, eighty-five died too soon after exposure to give definite information. There is no reason to suppose that any of the remaining one hundred twenty-eight were not susceptible to *P. capistrani.* Nor did the plasmochin prevent infection. So we may consider the infection rate for *P. capistrani* as 36.7 per cent.

When it is considered that in all respects the technic of handling the mosquitoes and birds was the same it is interesting that the infection rate in *P. cathemerium* was only 2.6 per cent whereas it was 36.7 per cent in *P. capistrani.* It is very difficult to explain this fact, especially since the oöcyst rate for *P. cathemerium* in 1930, using the same general technic and species of *Culex,* was 48 per cent.(17) What the sporozoite rate was at the same time we do not know, but in October, 1930, a batch of one hundred five *Culex quinquefasciatus* mosquitoes were dissected fifteen to twenty-five days after feeding on gametocyte carriers of *P. cathemerium.* In this lot there were forty oöcyst and thirty-two sporozoite infections, rates of 38.1 per cent for oöcysts and 30.5 per cent for sporozoites. Why there has been a marked change in the behavior of this parasite we cannot state. It is, of course, interesting to speculate whether or not similar changes occur in the plasmodia of man.

RESULTS OF EXPERIMENTS

Many of the ninety-three experiments in the series we are reporting were inconclusive and are not given in detail. In every experiment where controls as well as the birds receiving plasmochin remained negative the experiment was considered to be inconclusive. Only those experiments in which either the control or the plasmochin bird or both became infected are reported in detail below. A summary of the complete series has been presented in Tables 1 and 2. It is to be noted that we believe our technic in the negative experiments differed in no particular way from that used in the successful tests. Conditions were standard throughout, the only change being that already noted, from *P. cathemerium* to *P. capistrani.* In other words we cannot explain the negative results except on the general basis of the well-known natural variations in the susceptibility of mosquitoes to infections(19, 20) and a little understood and perhaps nonexistent immunity of certain birds to sporozoite infection. We found no canary immune to blood-saline inoculations of *P. capistrani* in over three hundred successive cases.

The first successful experiments were Nos. 19 and 21, which are displayed in Table 3. In the first case birds Y17 and Y18 were kept for five nights in a cage of mosquitoes which had fed on gametocyte-carrying birds L83, L95, L96, and L98, twenty-three days before the beginning of the experiment on July 20. On the mornings of July 21, 22, 23, 24, 25, and 26, at approximately 9 o'clock, bird Y18 was given an intramuscular injection of 0.00002 gram of a solution of plasmochin simplex. This solution was prepared by adding 4 cubic centimeters of distilled water to 1 cubic centimeter of plasmochin simplex solution as sold in ampoules. As stated on the label, this volume of plasmochin simplex solution contains 0.01 gram of plasmochin. Thus, 5 cubic centimeters of the resulting solution contained the 0.01 gram of plasmochin. Of this solution 0.1 cubic centimeter, or 0.0002 gram plasmochin constituted the daily injection. Bird Y17 was not given plasmochin. Both birds were negative for malaria by 30-minute blood-smear examinations July 20 and 27. Bird Y17 remained negative to repeated examinations until August 25 and died the 29th; but bird Y18, in spite of its plasmochin, became positive July 29, heavily so July 31, and died of its malaria August 7.

Experiment 21 was a replica of No. 19. The bird receiving plasmochin, Y30, became infected, but the control, Y31, did not. The latter was subsequently proved to be a susceptible bird by blood-saline inoculation. In both of these experiments the parasite was *Plasmodium cathemerium*. Hereafter, in this report, all experiments referred to were done with *Plasmodium capistrani*.

In Table 4 are summarized experiments 49, 51, 52, and 79, in each of which the birds were exposed to the bites of infected mosquitoes for only one night and the drug was given before and after this exposure. The dose of plasmochin simplex, in experiments 49, 51, and 52, was the same as used in the first two experiments reported above; namely, 0.0002 gram. In experiment 79 half of this amount was given each time, but injections were made at 8.45, 9.45, and 10.45 on the night of exposure and again the following morning at 6 a. m.

In each of these experiments the bird receiving plasmochin, D33, D37, D39, and J69, became infected in spite of the drug. One of the control birds, D40, was also infected. Control birds D34 and J70 were subsequently proved to be susceptible by blood-saline inoculations.

In experiments 39, 41, and 43 chinoplasmin was used instead of plasmochin simplex, the birds being exposed to infection for one night. The chinoplasmin is sold in ampoules of 2 cubic centimeters of a solution containing 0.02 gram plasmochin, 0.6 gram quinine hydrochloride, and 0.1 gram glucose. We diluted 2 cubic centimeters of this with 18 cubic centimeters of distilled water. Each intramuscular injection consisted of 0.05 cubic centimeter; that is, of 0.00005 gram plasmochin simplex and 0.0015 gram quinine hydrochloride. Bird C71 was given this amount daily for five days beginning on the morning after exposure. This bird became positive October 26, fourteen days after infection. The control bird, C70, which received no chinoplasmin, died too soon to be of any use in the experiment.

The same daily dose of chinoplasmin was given to birds C82 and D3, four times to the former and eight times to the latter, in each case beginning on the afternoon preceding the night of exposure. Each of these birds became infected in spite of the chinoplasmin. In each case the control bird also became infected, as shown in Table 5.

In experiments 48, 72, and 73, summarized in Table 6, both plasmochin simplex and chinoplasmin were used without success as prophylactics. Bird D25 received chinoplasmin, in the doses mentioned above, at 9 a. m. the day preceding the night of exposure. That afternoon it received 0.0002 gram of plasmochin simplex. The morning after exposure it was given another injection of the same amount of plasmochin simplex and the next day an injection of chinoplasmin. Yet it became infected after an incubation period two days shorter than that of its control bird D26. Bird Y91 received its first injection of plasmochin simplex at 11 p. m. the night of exposure and a second dose at 6 a. m. the following morning, with chinoplasmin the next day. This bird became infected, although its control Y92 did not. The susceptibility of Y92 was later proved by blood-saline inoculations. The same procedure was followed in bird Y93 which, with its control, became infected.

In Table 7 are shown the results of experiments 56, 57, 58, 66, 76, 77, and 81 in which the birds were exposed to infective mosquitoes for only two to three hours and not all night. In the first four experiments the usual dose of 0.0002 gram of plasmochin simplex was given just before and just after the birds were put into the mosquito cage, and again early the following morning. In the fourth experiment an additional dose was given on the second morning. Bird D55 died too soon to be of use, but its control bird became positive. Birds D57, D59, and D87 became infected in spite of the plasmochin. D56 and D58, control birds, become infected, but control bird D88 did not although it was later proved to be susceptible to a blood-saline inoculation.

In experiments 76, 77, and 81 plasmochin was given not only at the beginning and end of a two-hour exposure period but also in the middle of this period. That is, injections were made at 8.45, 9.45, and 10.45 p. m. with exposure to infective mosquitoes only from 8.45 to 10.45 p. m. It was necessary to reduce the dose to 0.0001 gram to avoid killing the birds. In these three experiments birds J64 and J73 became infected in spite of the plasmochin, but J65 did not. The control bird for J65 became infected, so that in this experiment, 77, the plasmochin may have had a true prophylactic effect. However, the control birds in experiments 76 and 81 did not become infected, so that it is not possible to point to experiment 77 as a clean-cut example of prophylactic plasmochin.

In all of the above experiments, Tables 3 to 7, infection was attempted by exposure to the bites of mosquitoes. The average number of mosquitoes in a cage was about twenty-five and the average number feeding on the two birds, control and experimental, was about twelve. It was not possible to determine whether more fed on one than on the other bird in a cage, but as each was tied in the same way it is not likely that there was much difference.

SPOROZOITE-SALINE INJECTIONS

Tables 8 to 11 summarize the results of experiments 60, 75, 40, and 46. These were experiments in which infection of the birds was attempted by needle injections of sporozoite-saline mixtures instead of by mosquito bites. This method fixed the time of inoculations exactly in relation to the injection of plasmochin.

In experiment 60, Table 8, seventy-five mosquitoes were used. These had fed on a gametocyte-carrying bird, D4, twenty days prior to this experiment. Wings, legs, head, and abdomen were carefully dissected away from the thorax of each mosquito, quieted by a minimum amount of chloroform. A thorax-saline mixture was made by grinding the material in a mortar and pestle, using 3 cubic centimeters of physiologic saline. Each bird, D71, D72, D73, D74, D75, and D76, received an injection of 0.2 cubic centimeter of the mixture at 9 a. m. Birds D71, D73, and D75 had received 0.0002 gram of plasmochin simplex at 8.50 a. m.; that is, ten minutes prior to the sporozoite injection. The drug was received in the left and the sporozoites in the right breast. The inoculum was perhaps equivalent to the total sporozoite content of five mosquitoes, a rather large infective dose. This, however, assumes that all of the mosquitoes were infected, which is very doubtful. Two birds failed to become infected. One, D73, had had plasmochin and the other, D76, had not.

The general procedure in experiment 75, Table 9, was the same as in the one just described. In this experiment, No. 75, however, a smaller inoculum was used and plasmochin was given not only just prior to the injection of sporozoites but also in the same dose four and one-half hours later. The same number of mosquitoes were used, but they had been kept thirty-three days after infection. The mixture contained 4 cubic centimeters of saline instead of 3 and the inoculum was 0.15 cubic centimeter of the mixture instead of 0.2 as in experiment 60. Thus, each bird received, perhaps, the equivalent of the total sporozoite content of 2.7 mosquitoes.

In this experiment, of the six birds Y97, Y98, Y99, Y100, J59, and J60, only two became infected. One, Y99, had received plasmochin and the other, Y98, had not. The incubation period was the same in each bird. Birds Y97, Y100, and Y60 died too soon to be of any use.

In experiment 40, Table 10, chinoplasmin was used instead of plasmochin simplex. The dose, 0.00005 gram plasmochin and 0.0015 gram quinine hydrochloride, was given ten minutes before the sporozoites and was repeated on the three succeeding days. In this case, seventy mosquitoes were used with 4 cubic centimeters of physiologic saline. Birds C72 to C81 were used and of these birds C72, C76, and C79 died promptly. Birds C73, C74, and C75 were, therefore, the chinoplasmin birds and of these only C73 became infected. Birds C74 and C75 were subsequently proved to be susceptible by blood-saline inoculation. Of the four useful control birds only one, C78, became infected. Bird C77, C80, and C81 remained negative without the aid of drugs. Bird C80 was subsequently proved to be susceptible. This experiment is further proof of the need for an adequate number of controls in such studies. To say that only one out of three chinoplasmin birds became infected may seem significant until it is realized that only one out of four control birds, inoculated in the same way but having no prophylactic, became infected.

In experiment 46, Table 11 seventy-five mosquitoes with 4 cubic centimeters of saline were used. Of this mixture the inoculum consisted of 0.2 cubic centimeter. Chinoplasmin, in the usual dose given above, was administered not only just before the sporozoites but also on the four following mornings. Birds D9 to D32 were used. Of these, birds D9, D11, D14, D16, D19, and D22 died promptly. Birds D13, D15, and D18 did not live long enough to be conclusively negative. That left of the chinoplasmin birds, D10 and D12. For controls there were left birds D17, D20, and D21. One of the two chinoplasmin birds became infected in spite of the drug. The other, D10, remained negative until proved to be a susceptible bird by blood-saline inoculation. One of the three control birds, D21, became infected. The other two remained negative without the aid of chinoplasmin and were subsequently proved to be susceptible by blood-saline injections.

SPOROZOITE-PLASMOCHIN MIXTURE

In experiment 82, Table 12, the experimental procedure was changed by adding the plasmochin directly to the sporozoite-saline mixture. Using one hundred sixty-two mosquitoes with 6 cubic centimeters of physiologic saline, a mixture was made in the usual way. Of this mixture, well stirred, 2.7 cubic centimeters were put in a small glass beaker, into which was also added 0.3 cubic centimeter of the usual plasmochin simplex solution as prepared in our laboratory and described above. This added 0.0006 gram plasmochin simplex to the sporozoite mixture and this combination was allowed to stand for fifteen minutes. At the end of this time 0.1 cubic centimeter of the sporozoite-saline-plasmochin mixture was injected into each of six birds, J75 to J80. Immediately thereafter 0.1 cubic centimeter of the original sporozoite-saline mixture (no plasmochin), which had also been standing in a glass beaker for fifteen minutes, was injected into each of six birds, J81 to J86.

We do not know the volume of a canary's blood but estimate it at about 1 cubic centimeter. The maximum amount of plasmochin which can be tolerated without symptoms is 0.0002 gram, and this is a therapeutic dose. In the experiment we are describing, the amount of plasmochin mixed with the sporozoites, therefore, makes a concentration which is probably of the same magnitude as, or slightly greater than, the concentration of this drug in the blood of a bird following the usual injections.

Of the birds used in this experiment J76, J78, and J82 died within a day or two. There remained, therefore, four birds which received the sporozoite-saline-plasmochin mixture; namely, J75, J77, J79, and J80. Three of these, J77, J79, and J80, became infected in spite of the plasmochin. Of the five controls which lived long enough to be of service, all became infected. The average prepatent period in the plasmochin birds was 13 days, in the controls 10.4 days. It seems possible that plasmochin had some direct action on the sporozoites, but it was not great and is not proven by this experiment. Other experiments, 83 to 93, were not successful, all of the birds either dying too soon to be of service or else all, controls and plasmochin birds alike, remaining negative. All attempts at infecting birds with sporozoite-saline-plasmochin or with the plain sporozoite-saline mixtures after half hour or one-hour delays failed.

PLASMOCHIN-BLOOD-SALINE INJECTIONS

In the final experiment we mixed plasmochin with a blood-saline inoculum (no sporozoites). Approximately 0.3 cubic centimeter of blood from bird Z42, which had a one-plus blood smear at the time, was added to 6 cubic centimeters of physiologic saline. To 2.7 cubic centimeters of this mixture was added 0.3 cubic centimeter, or 0.0006 gram, of the laboratory solution of plasmochin simplex, prepared as noted above. After fifteen minutes birds S88, S89, and S90 were each given 0.1 cubic centimeter of the blood-saline-plasmochin mixture, and birds S85, S86, and S87 were then given 0.1 cubic centimeter of the plain blood-saline mixture. All three of these last-named control birds became infected. Only one, S90, of the three birds receiving blood-saline-plasmochin mixture became infected. The other two were subsequently proved to be susceptible birds. In this experiment the plasmochin apparently had a definite inhibitory effect.

CONCLUSIONS

1. Although plasmochin acts in vivo on the asexual stages of *Plasmodium cathemerium* to prevent the development of infection by needle inoculations and acts similarly, as concluded below, on the asexual forms of *Plasmodium capistrani* in vitro to prevent inoculation, neither plasmochin simplex nor chinoplasmin, in the maximum doses which will not cause toxic symptoms, is a prophylactic against avian malaria when sporozoites are injected either in saliva by mosquitoes or in saline mixtures by needle.

2. Plasmochin simplex in actual contact with the sporozoites of avian malaria for fifteen minutes in a glass beaker does not destroy or inactivate them.

3. Plasmochin simplex in actual contact with the asexual forms of *Plasmodium capistrani* for fifteen minutes in a glass beaker appears to have an inactivating or destructive effect on them.

TABLE 1.—*Summary of general results of experiments 1 to 38 with Plasmodium cathemerium and prophylactic plasmochin.*[a]

Description.	Classification.				
	+	O	S	D	T
Birds not receiving plasmochin:					
Number	0	40	27	5	45
Per cent	0	--------	--------	--------	--------
Birds receiving plasmochin:					
Number	2	35	19	6	43
Per cent	4.7	--------	--------	--------	--------
Total number	2	75	46	11	88
Total per cent	2.3	--------	--------	--------	--------

[a] +, bird became infected.

O, bird did not become infected as determined by 30-minute examination of blood smears for a period of at least fourteen days after exposure.

S, number of negative birds in group O for which it was possible to prove definite susceptibility to *P. cathemerium* by subsequent blood inoculations.

D, birds dying less than fourteen days after exposure. (None positive.)

T, total birds used, the sum of columns +, O, and D.

TABLE 2.—*Summary of general results of experiments 39 to 93 with Plasmodium capistrani and prophylactic plasmochin.*[a]

Description.	Classification.				
	+	O	S	D	T
Birds not receiving plasmochin:					
Number	24	46	36	32	102
Per cent	23.5	--------	--------	--------	--------
Birds receiving plasmochin:					
Number	23	35	19	53	111
Per cent	20.7	--------	--------	--------	--------
Total number	47	81	42	85	213
Total per cent	22.1	--------	--------	--------	--------

[a] +, bird became infected.

O, bird did not become infected, as determined by 30-minute examination of blood smears for a period of at least fourteen days after exposure.

S, number of negative birds in group O for which it was possible to prove definite susceptibility to *P. capistrani* by subsequent blood inoculations.

D, birds dying less than fourteen days after exposure. (None positive.)

T, total birds used, the sum of columns +, O, and D.

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TABLE 3.—*Attempts to use plasmochin simplex as a prophylactic in avian malaria in mosquito-borne infections. Birds exposed five nights to bites of mosquitoes infected with Plasmodium cathemerium.*

Experiment No.	Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.	Remarks.
		From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++		
	1931					*g.*						
19	July 20–26	L83 L95	23 23	Y17	None.	----	----	July 20, 27, to Aug. 25.	----	----	Aug. 29, 1931.	
		L96 L98	23 23	Y18	[a] P.S.	0.0002	July 21, 22, 23, 24, 25, 26, 9 a. m.	July 20–27	July 29–30	July 31; Aug. 1–6.	Aug. 7, 1931.	
21	Aug. 9–14	N1	20	Y30	[a] P.S.	0.0002	Aug. 10, 11 12, 13, 14, 15, 9 a. m.	Aug. 9–23	Aug. 25, 27; Sept. 2, 4.	Aug. 29, 31	Mar. 20, 1932	
				Y31	None.	----	----	Aug. 9 to Sept. 7.	----	----	Sept. 15, 1931.	Susceptibility proved.

[a] Plasmochin simplex.

TABLE 4.—*Attempts to use plasmochin simplex as a prophylactic in avian malaria in mosquito-borne infections. Birds exposed for one night to bites of mosquitoes infected with Plasmodium capistrani.*

Experiment No.	Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.	Remarks.
		From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++		
	1931					g.						
49	Dec. 3	C87	28	D33	[a] P.S.	0.0002	Dec. 3, 4 p. m; Dec. 4, 7.15 a. m.	Dec. 3, 12	Dec. 14, 16	Dec. 18, 19, 21.	Dec. 21, 1931	
			28	D34	None.			Dec. 3, 1931; Jan. 2, 1932.			Jan. 16, 1932	Subsequently proved to be susceptible.
51	Dec. 3	C78	26	D37	[a] P.S.	0.0002	Dec. 3, 4 p. m; Dec. 4, 7.15 a. m.	Dec. 3	Dec. 12	Dec. 14, 16, 18, 19.	Dec. 21, 1931	
		C86	26	D38	None.			Dec. 3–Jan. 2			Jan. 3, 1932	
52	Dec. 9	C89	23	D39	[a] P.S.	0.0002	Dec. 9, 7 p. m; Dec. 10, 7.30 a. m.	Dec. 9	Dec. 26, 28, 29.	Dec. 19, 22, 24.		Still alive.
				D40	None.			Dec. 9, 19, 22	Dec. 24, 26	Dec. 28, 29		Do.
79	Jan. 22	D54	23	J69	[a] P.S.	0.0001	Jan. 22, 8.45, 9.45, 10.45 p. m.; Jan. 23, 6 a. m.	Jan. 22, 28, 30; Feb. 1.	Feb. 3	Feb. 5, 8, 10	Apr. 10, 1932; killed.	
		D56	23	J70	None.			Jan. 22, 28, 30; Feb. 1–18.			Feb. 26, 1932	Subsequently proved to be susceptible.

[a] Plasmochin simplex.

TABLE 5.—*Attempts to use chinoplasmin as a prophylactic in avian malaria in mosquito-borne infections. Bird exposed for one night to bites of mosquitoes infected with Plasmodium capistrani.*

Experiment No.	Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.
		From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++	
						g.					
39	Oct. 12	C48	26	C70	None.			Oct. 12			Oct. 16, 1931.
			26	C71	Chin.	P.S., 0.00005 Q., 0.0015	Oct. 13, 14, 15, 16, 17, 9 a. m.	Oct. 12		Oct. 26, 27, 28, 30.	Oct. 31, 1931.
41	Oct. 15	C48	24	C82	Chin.	P.S., 0.00005 Q., 0.0015	Oct. 15, 16, 17, 18.	Oct. 15, 24, 25, 26.	Oct. 27, 29, 31.		Jan. 5, 1932.
		C53	24	C83	None.			Oct. 15, 24	Oct. 25, 27, 29, 31.		Mar. 20, 1932.
43	Nov. 16	C71	20	D3	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 16, 3.30 p. m.; 17, 18, 19, 20, 21, 22, 23.	Nov. 16	Nov. 24		Nov. 26, 1931.
			20	D4	None.			Nov. 16	Nov. 24	Nov. 27; Dec. 1, 3.	De. 5, 1931.

[a] P.S., plasmochin; Q, quinine hydrochloride; Chin., chinoplasmin..

TABLE 6.—*Attempts to use both chinoplasmin and plasmochin simplex as a prophylactic in avian malaria in mosquito-borne infections. Birds exposed for one night to bites of mosquitoes with Plasmodium capistrani.*

Experiment No.	Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.	Remark.
		From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++		
						g.						
	Nov. 24	C87	20	D25	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 24, 9 a.m.; Nov. 26.	Nov. 24; Dec. 1.	Dec. 3, 5, 7, 17.	Dec. 8	Jan. 6, 1932	
					P.S.	0.0002	Nov. 24, 4 p.m.; Nov. 25.					
				D26	None.			Nov. 24; Dec. 1, 3.	Dec. 5, 7	Dec. 8	Dec. 12	
72	Jan. 13	D61 D64	22 22	Y91	P.S.	0.0002	Jan. 13, 11 p.m.; Jan. 14, 6 a.m.	Jan. 13, 19	Jan. 21, 23, 25, 30.	Jan. 26, 28	Mar. 20, 1932; killed.	
				Y91	Chin.	P.S., 0.00005 Q., 0.0015	Jan. 15					
				Y92	None.			Jan. 13–28; Feb. 17–24.			Mar. 4, 1932.	Subsequently proved to be susceptible.
73	Jan. 13	D62 D63	21 21	Y93	P.S.	0.0002	Jan. 13, 11 p.m.; Jan. 14, 6 a.m.	Jan. 13, 19		Jan. 23, 25	Jan. 26, 1932.	
					Chin.	P.S., 0.00005 Q., 0.0015	Jan. 15					
				Y94	None.			Jan. 13	Jan. 19	Jan. 21, 23, 25, 26, 28, 30.	Mar. 20, 1932; killed.	

TABLE 7.—*Attempts to use plasmochin simplex as a prophylactic in avian malaria in mosquito-borne infection. Birds exposed only for two to three hours to bites of mosquitoes infected with Plasmodium capistrani.*

Experiment No.	Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.	Remarks.
		From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++		
						g.						
56	Dec. 14	D2	21	D54	None.			Dec. 14, 21	Dec. 23	Dec. 26, 28	Dec. 31, 1931	
				D55	P.S.	0.0002	Dec. 14, 8.20, 11.20 p. m.; Dec. 15, 5.45 a. m.	Dec. 14			Dec. 16, 1931	
57	Dec. 14	D2	21	D56	None.			Dec. 14	Dec. 21	Dec. 23. 26, 28.	Feb. 12, 1932	
				D57	P.S.	0.0002	Dec. 14, 8.20, 11.20 p. m.; Dec. 15, 5.45 a. m.	Dec. 14, 21, 23.	Dec. 26	Dec. 28, 30	Dec. 31, 1931	
58	Dec. 14	D1	20	D58	None.			Dec. 14, 21, 23.	Dec. 26, 28, 31.			Still alive.
				D59	P.S.	0.0002	Dec. 14, 8.20, 11.20 p. m.; Dec. 15, 5.45 a. m.	Dec. 14, 21, 23.	Dec. 26		Dec. 28, 1931	

66	Dec. 30	D21	20	D87	P.S.	0.0002	Dec. 30, 9.40, 11.50 p. m.; Dec. 31, 8.30 a. m.; Jan. 1, 9 a. m.	Dec. 30	Jan. 7, 9	Jan. 11. 13, 15.		Still alive.
				D88	None.			Dec. 30; Jan. 7, 27.			Apr. 7, 1932	Subsequently proved to be susceptible.
76	Jan. 22	D54	24	J62	None.			Jan. 22, 28, 30; Feb. 1–18.			Apr. 10, 1932; killed.	Do.
		D56	24	J64	P.S.	0.0001	Jan. 22, 8.45, 9.45, 10.45 p. m.	Jan. 22, 28	Jan. 30; Feb. 1, 3, 8.	Feb. 5	Apr. 10, killed.	
77	Jan. 22	D54	23	J65	P.S.	0.0001	Jan. 22, 8.45, 9.45, 10.45 p. m.	Jan. 22, 28, 30; Feb. 1–18.			Apr. 23, 1932	
		D56	23	J66	None.			Jan. 22, 28, 30.	Feb. 1–3	Feb. 5	Feb. 7, 1932	
81	Jan. 22	D54	24	J73	P.S.	0.0001	Jan. 22, 8.45, 9.45, 10.45 p. m.	Jan. 22, 28, 30, Feb. 1–3.	Feb. 5–10	Feb. 8	Apr. 10, 1932; killed.	
		D56	24	J74							Apr. 10, 1932; killed.	Subsequently proved to be susceptible.

TABLE 8.—*Results of experiment 60 in which plasmochin simplex was used in an attempt to prevent infections of P. capistrani.*

Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.
	From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++	
					g.					
Dec. 22, 1931	D4	20	D71	P.S.	0.0002	Dec. 22, 8.50 a. m.	Dec. 22, 29, 31	Jan. 2, 4, 6, 11	Jan. 8	[a] 1931.
		20	D72	None.			Dec. 22, 29	Dec. 31; Jan. 2, 4, 6, 8.		Feb. 20, 1932.
		20	D73	P.S.	0.0002	Dec. 22, 8.50 a. m.	Dec. 22			Dec. 23, 1931.
		20	D74	None.			Dec. 22	Jan. 2, 4	Jan. 6, 8	Jan. 9, 1932.
		20	D75	P.S.	0.0002	Dec. 22, 8.50 a. m.	Dec. 22	Jan. 2, 4		Jan. 6, 1932.
		20	D76	None.			Dec. 22, 29, 31; Jan. 2.			Jan. 3, 1932.

[a] Still alive.

TABLE 9.—*Results of experiment 75 in which plasmochin simplex was used in an attempt to prevent infections of P. capistrani in birds by sporozoites-saline injections.*

Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.
	From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++	
Jan. 19, 1932	D21 D25	33	Y97	P.S.	*g.* 0.0002	Jan. 19 11.20 a. m., 3.30 p. m.	Jan. 19			Jan. 20, 1932.
		33	Y98	None.			Jan. 19 to Feb. 1.	Feb. 3, 5, 6		Mar. 20, 1932; killed.
		33	Y99	P.S.	0.0002	Jan. 19, 11.20 a. m., 3.30 p. m.	Jan. 19 to Feb. 1.	Feb. 3, 5, 6		Do.
				Chin.		Jan. 20				
		33	Y100	None.			Jan. 19			Jan. 20, 1932.
		33	J59	P.S.	0.0002	Jan. 19, 11.20 a. m., 3.30 p. m.	Jan. 19–29			Jan. 31, 1932.
		33	J60	None.			Jan. 19			Jan. 20, 1932.

TABLE 10.—*Results of experiment 40 in which chinoplasmin was used in an attempt to prevent infections of P. capistrani in birds by sporozoites-saline injections.*

Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.	Remarks.
	From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++		
Oct. 15, 1932	C48	28	C72	Chin.	g. P.S., 0.0005 Q., 0.0015	Oct. 15, 16, 10 a. m.				Oct. 17, 1931.	
		28	C73	Chin.	P.S., 0.0005 Q., 0.0015	Oct. 15, 16, 17. 18, 10 a. m.	Oct. 15, 26	Oct. 28, 29, 30.		Nov. 11, 1931.	
		28	C74	Chin.	P.S., 0.0005 Q., 0.0015	Oct. 15, 16, 17, 18, 10 a. m.	Oct. 15, 26, 28, 30; Nov 1-9			Nov. 29, 1931.	Subsequently proved susceptible.
		28	C75	Chin.	P.S., 0.0005 Q., 0.0015	Oct. 15. 16, 17. 18, 10 a. m.	Oct. 15, 26, 28, 30, Nov. 1-9			Jan. 15, 1932.	Do.
		28	C76	Chin.	P.S., 0. 0005 Q., 0.0015	Oct. 15, 10 a. m.				Oct. 16, 1931.	
		28	C77	None.			Oct. 15, 27, 29, 31; Nov. 1-9				
		28	C78	Chin.			Oct. 15, 27, 29, 31.	Nov. 1, 2,	Nov. 6, 7 9.	Nov. 9, 1931.	
		28	C79	Chin.						Oct. 17, 1931.	

Oct. 15, 1932	C48	28	C80	None.	--------	--------	Oct. 15, 27, 29, 31; Nov. 1-9	--------	--------	Nov. 19	Do.
		28	C81	None.	--------	--------	Oct. 15, 27, 29, 31; Nov. 1-9	--------	--------	Nov. 15	

TABLE 11.—*Results of experiment 46 in which chinoplasmin was used in an attempt to prevent infections of P. capistrani in birds by sporozoites-saline injections.*

Date.	Mosquitoes infected.		Bird No.—	Prophylaxis, if any.			Results. Blood smears.			Died.	Remarks.
	From bird No.—	Days before experiment.		Drug.	Amount.	Given.	Negative.	+ ++	+++ ++++ +++++		
Nov. 20, 1931	C71	24	D9	Chin.	*g.* P.S., 0.00005 Q., 0.0015	Nov. 20, 2.40 p. m., Nov. 21, 22, 23.	Nov. 20	----	----	Nov. 24, 1931.	
		24	D10	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 20, 2.40 p. m., Nov. 21, 22, 23, 24, 25, 26.	Nov. 20, 28; Dec. 1–21	----	----		Still alive May 1, 1932. Subsequently proved susceptible.
		24	D11	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 20, 2.40 p. m., Nov. 21, 22, 23, 24.	Nov. 20	----	----	Nov. 25	
		24	D12	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 20, 2.40 p. m.; Nov. 21, 22, 23, 24.	Nov. 20, 28; Dec. 1–4	Dec. 5, 7, 11–17.	Dec. 9	----	Still alive.
		24	D13	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 20, 2.40 p. m.; Nov. 21, 22, 23, 24.	Nov. 20, 28; Dec. 1	----	----	Dec. 2	

Nov. 20, 1931	C71	24	D14	Chin.			Nov. 20			Nov. 20	
		24	D15	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 20, 2.45 p. m., Nov. 21, 22, 23, 24.	Nov. 20, 28; Dec. 1			Dec. 1	
		24	D16	Chin.	P.S., 0.00005 Q., 0.0015	Nov. 20, 2.45 p. m., Nov. 21, 22, 23, 24.	Nov. 20			Nov. 25	
		24	D17	None.			Nov. 20, 28; Dec. 1–21				Still alive. Subsequently proved susceptible.
		24	D18	None.			Nov. 20, 28; Dec. 1			Dec. 3	
		24	D19	None.			Nov. 20			Nov. 22	
		24	D20	None.			Nov. 20, 28; Dec. 1–21				Do.
		24	D21	None.			Nov. 20, 28	Dec. 1–4	Dec. 5	Dec. 10	
		24	D22	None.			Nov. 20			Nov. 22	

TABLE 12.—*Results of experiment 82 in which plasmochin simplex was added to sporozoites-saline mixtures in an attempt to prevent infections of P. capistrani in birds following injections of these mixtures.*

Date.	Mosquitoes infected.		Bird No.—	Control or experiment.	Results. Blood smears.			Died.	Remarks.
	From bird No.—	Days before experiment.			Negative.	+ ++	+++ ++++ +++++		
Jan. 23, 1932	D54 D56	25	J75	[a] E	Jan. 23, 29, 31; Feb. 2–18.			Apr. 10, 1932 (K)	Subsequently proved susceptible.
		25	J76	E	Jan. 23			Jan. 24, 1932	
		25	J77	E	Jan. 23, 29, 31	Feb. 2, 4, 6, 8, 11		Apr. 10, 1932 (K)	
		25	J78	E	Jan. 23			Jan. 25, 1932	
		25	J79	E	Jan. 23, 29, 31	Feb. 2, 4	Feb. 6, 8, 11	Feb. 15, 1932	
		25	D80	E	Jan. 23, 29, 31; Feb. 2–8.	Feb. 11–16		Feb. 17, 1932	
		25	J81	C	Jan. 23, 29, 31; Feb. 2.	Feb. 4	Feb. 6, 8, 11	Feb. 15, 1932	
		25	J82	C	Jan. 23			Jan. 23, 1932	
		25	J83	C	Jan. 23, 29, 31; Feb. 2.	Feb. 4, 6	Feb. 8, 11	Apr. 10, 1932 (K)	
		25	J84	C	Jan. 23, 29, 31	Feb. 2, 4, 8	Feb. 6	Apr. 10, 1932 (K)	
		25	J85	C	Jan. 23, 29, 31	Feb. 2, 4, 6, 11	Feb. 8	Apr. 10, 1932	
		25	J86	C	Jan. 23, 29	Jan. 31; Feb. 2, 4, 11.	Feb. 6, 8	Feb. 13, 1932	

[a] E, experiment bird; C, control bird, no drug; K, killed.

TABLE 13.—*Results of experiment 94 in which plasmochin simplex was added to blood-saline mixtures in an attempt to prevent infections of P. capistrani in birds following injections of these mixtures.*

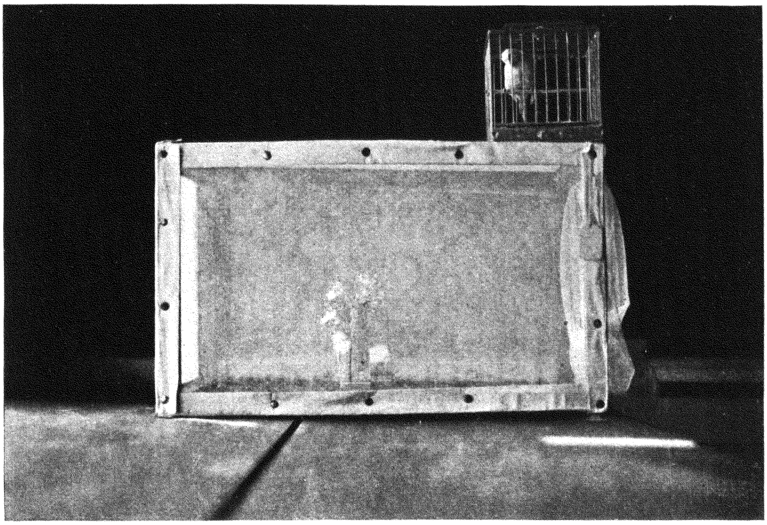
Date.	Bird No.—	Experiment or control.	Results. Blood smears.			Died.	Remarks.
			Negative.	+ ++	+++ ++++ +++++		
April 16, 1932	C85	[a] C	Apr. 16, 22, 23	Apr. 25, 26			Still alive.
	S86	C	Apr. 16, 22	Apr. 23		Apr. 24, 1932	
	S87	C	Apr. 16, 22, 23	Apr. 25, 26			Do.
	S88	E	Apr. 16, 22, 23–30				Subsecuently proved susceptible.
	S89	E	Apr. 16, 22, 23–30				Do.
	S90	E	Apr. 16, 22, 23	Apr. 26, 27, 28, 29			Still alive.

[a] C, control bird; E, experimental bird.

ILLUSTRATION

PLATE 1

FIG. 1. Mosquito and bird cages used in the experiment.
2. A bird cage inside a mosquito cage.



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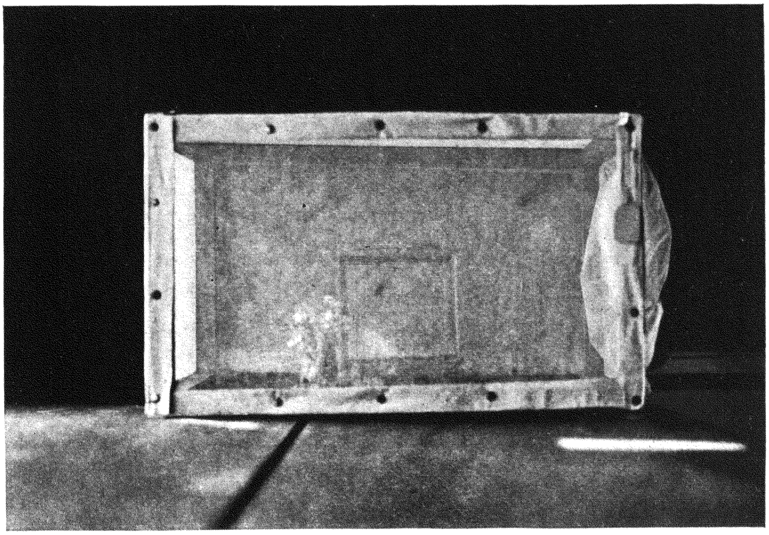

2

PLATE 1.

UNIV. OF MICH.

AVIAN MALARIA STUDIES, VIII

THE BLEEDING TIME IN CANARIES; NORMAL AND IN MALARIA[1]

By PAUL F. RUSSELL

Of the International Health Division of the Rockefeller Foundation

FIVE PLATES AND ONE TEXT FIGURE

INTRODUCTION

Duke(1, 2) first described the simple but informative bleeding-time test of the blood in man. His method and definition may best be given in his own words:

> Make a small cut in the lobe of the ear. At half minute intervals blot up on absorbent paper all the blood which has flowed out. This gives a series of blots. Each blot represents the volume of the blood flowing out in its respective half minute. From the rate of decrease in the size of the blots one can see at a glance the rate of decrease in the intensity of the hemorrhage. The duration of such a hemorrhage is called the bleeding time. On first thought one might believe that the bleeding time depends largely on the size of the cut. This, however, within certain limits, is not the case.

It must be emphasized that this bleeding time may or may not vary as the coagulation time. It is an independent test influenced, according to Kilduffe,(3) chiefly by (*a*) the thromboplastin content of the tissue juice, (*b*) the elasticity of the skin, and (*c*) the mechanical and chemical action of the blood plates. MacKay(4) holds that the most important factor in controlling the duration of bleeding time is not the number of blood platelets in circulation but the ability of the vessel wall to contract. As noted by Duke the size of the cut is not, within reason, a factor. It is usual, however, to make the cut of such a size that the first drop of blood when transferred to blotting paper will have a diameter of 1 to 2 centimeters.

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[1] The experiments herein reported were done at the Bureau of Science, Manila, in the laboratory of malaria investigations, of which the author is chief and which is jointly supported by the Bureau of Science and the International Health Division of the Rockefeller Foundation. Mrs. I. Ramos, microscopist of malaria investigations, assisted in the experiments.

Not only is the bleeding time independent of the coagulation time, but it is said to be not greatly affected by anæmia and it is not prolonged in hæmophilia. Normally, in man, it is from one to four minutes, being somewhat longer in the first week of life. The bleeding time has been found to be prolonged from ten to ninety minutes or more in (*a*) cases of thrombopenia, as in purpura hæmorrhagica, and (*b*) in those conditions causing a reduced fibrinogen content of the blood, as in chloroform and phosphorus poisoning.

The normal platelet count in man is from 200,000 to 400,000 per cubic millimeter. When the platelets number more than 60,000 there is only a slight increase in the bleeding time. It is somewhat greater when there are between about 30,000 and 60,000 platelets and is very markedly greater when there are less than 30,000. In all such counts the coagulation time may be normal, but the clot retraction and the quality of the clot will be modified.

In 1921, I(5) examined a number of normal men and found their average bleeding time to be 2.5 minutes. The stab wound in the ear lobe in each case was made as nearly the same size as possible. In one individual the bleeding time was 2.5 minutes from a stab wound in the left ear lobe, but with a slightly deeper and longer incision in the right lobe it was 6 minutes. At the same time a patient (P. W.) with chronic purpura hæmorrhagica was under observation. In this case I found a bleeding time of 27 minutes and a platelet count of 16,000. This patient's blood clot was nonretracting in type, but the coagulation time was normal. There was no calcium deficiency.

The significance of a prolonged bleeding time in man is by no means clear and, it must be noted, it is still less evident in birds. In man it is believed by some that the hæmorrhage from a small stab wound in the skin is checked by the formation of platelet thrombi in the injured capillaries. When the platelets are reduced markedly these thrombi do not form with normal speed and the bleeding time is therefore prolonged. Since there is no reduction in numbers of platelets in hæmophilia the thrombi form at normal speed and there is no prolonged bleeding time. Coagulation time may not be affected coincidently with bleeding time because, although the platelets are reduced in number, there may still be plenty of prothrombin and fibrinogen to allow the normal reaction which results in fibrin and coagulation. But since the character of the clot depends apparently on the numbers of formed elements in the blood, the clot will not be normal when the platelet count is low.

It may be worth while to recall that coagulation seems to depend on the formation of fibrin. This is formed apparently in two combinations, as follows: (*a*) Prothrombin + calcium salts = thrombin; (*b*) thrombin + fibrinogen = fibrin. A widely accepted theory of coagulation is still that of Howell, (6) as follows:

> In circulating blood we find as constant constituents fibrinogen, prothrombin, calcium salts and antithrombin. The last-named substance holds the prothrombin in combination and thus prevents its conversion or activation into thrombin.
>
> When blood is shed the disintegration of the blood platelets furnishes material (thromboplastin) which combines with the anti-thrombin and liberates the prothrombin; the latter is then activated by the calcium and acts on the fibrinogen.

Going back to the question of the bleeding time, according to Mallory and Wright (7) the situation is confused by the fact that coagulation and bleeding times may be prolonged in conditions in which there is no clearly demonstrable qualitative or quantitative alteration in the platelets. In some conditions there seems to be a positive correlation between lack of available calcium in the blood and a prolonged bleeding time, as for example, in certain types of jaundice. One of the best reviews of the subject of blood platelets is that of MacKay. (4)

BLEEDING TIME IN BIRDS

In discussing the bleeding time of birds it must be noted that according to most authorities birds have no blood platelets, an opinion to which I agree. Quoting Wright, (8)

> According to my own and others' observations, bodies that are undoubtedly and obviously blood plates are found only in the blood of mammals . . . The so-called spindle cell or fusiform corpuscles of the birds, amphibia, reptiles and fishes have been claimed by some writers to be the morphological equivalents of blood plates, but my studies of the blood of these vertebrates have not led me to accept this view.

These spindle cells, sometimes called hæmatoblasts or thrombocytes, may function similarly to the blood platelets of mammals, but they are certainly not homologous to them. They are more probably, as Wright (8) suggests, homologous to the mammalian megakaryocytes from which the blood platelets are believed to be detached.

The spindle cell of birds is about as long as a red cell but is narrower. The nucleus is round and nearly equal in diameter to the cell itself. The cytoplasm stains a faint purple and the nucleus a deeper shade of purple with Wright's or Giemsa's stain.

Normal fowl blood, according to Burnett,(9) Kaupp,(10) and Klieneberger(11) contains from 2,000,000 to over 4,000,000 red cells per cubic millimeter, from about 45,000 to 55,000 thrombocytes per cubic millimeter, and from about 18,000 to 30,000 leucocytes.

Ben-Harel(12) found the normal red-blood-cell count in canaries to be from 4,500,000 to 5,200,000 per cubic millimeter, the mean being about 4,500,000.

In a series of seventy-two red-cell counts in twenty-four normal canaries the average number of erythrocytes has been 3,350,000 per cubic millimeter. I have not found any reports of spindle-cell counts in canaries. In a series of counts in eight normal canaries we have found that on the average the thrombocytes are only 1.6 per cent as numerous as the erythrocytes. This would indicate normal counts of between 50,000 to 60,000 per cubic millimeter.

No reports of bleeding time in birds, normal or otherwise, have been found in a survey of this literature. It seemed worth while to find out whether or not any notable changes occur in the bleeding time of canaries during the course of malaria.

PROCEDURE

The birds used in these experiments were canaries (*Serinus canarius.*) The parasite was *Plasmodium cathemerium* Hartman, 1927. Infections were produced in the usual way by intramuscular injections of blood from birds known to be infective.

To obtain the bleeding time the procedure was essentially that of Duke(1, 2) as outlined above. Blood was taken from uniform punctures made with a Hagedorn needle on the inner side of the legs of the birds. The rate of flow of blood in birds is much higher than in man and the bleeding time much shorter. Therefore, the intervals between blotting in these experiments were only ten instead of thirty seconds. One assistant marked time while the other applied the absorbent paper. All of the tests reported in this paper were done by the same microscopist, using the same technic in the same way. They are strictly comparable in this sense. (See illustrations.)

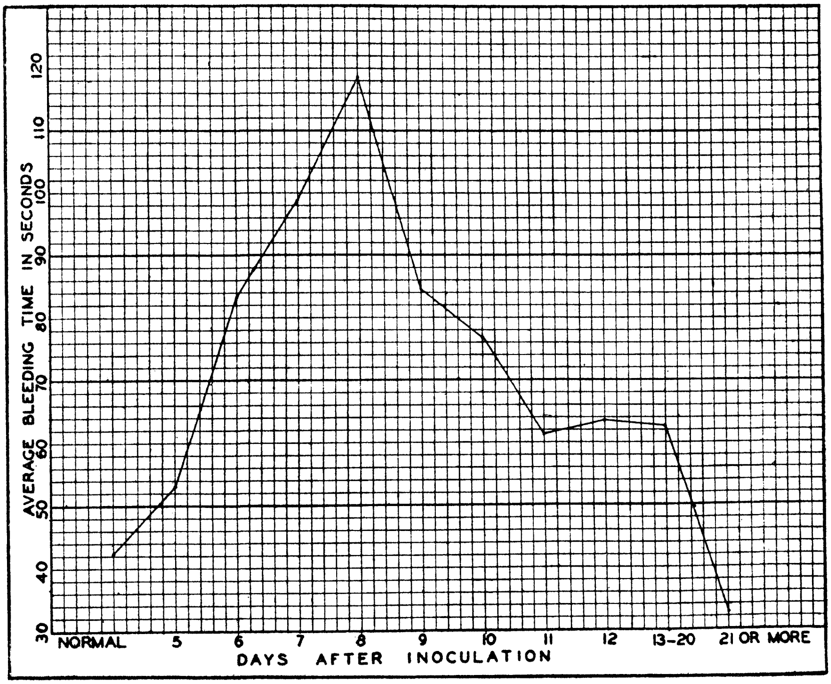

FIG. 1. Average bleeding time in seconds in groups of birds, normal and at varying periods after inoculations. (See Tables 1 to 11.)

TABLE 1.—*Bleeding time in normal birds (before inoculation with malaria).*

[Average time 42.4 ± 10.4 seconds, in 180 tests.]

Bird No.	Bleeding time.		Bird No.	Bleeding time.		Bird No.	Bleeding time.	
	Date.	Seconds.		Date.	Seconds.		Date.	Seconds.
	1931			**1931**			**1931**	
----------	May 18	50	----------	May 18	70	----------	May 18	40
----------	May 18	60	----------	May 18	40	----------	May 18	30
----------	May 18	50	----------	May 18	30	----------	May 18	40
----------	May 18	50	----------	May 18	30	----------	May 18	40
----------	May 18	70	----------	May 18	20	----------	May 18	30
----------	May 18	60	----------	May 18	60	----------	May 18	30
----------	May 18	50	----------	May 18	50	----------	May 18	50
----------	May 18	50	----------	May 18	40	----------	May 18	50
----------	May 18	60	----------	May 18	20	----------	May 18	30
----------	May 18	50	----------	May 18	20	----------	May 18	50
----------	May 18	40	----------	May 18	20	----------	May 18	20
----------	May 18	40	----------	May 18	40	----------	May 18	40
----------	May 18	50	----------	May 18	50	----------	May 18	40
----------	May 18	30	----------	May 18	50	----------	May 18	30
----------	May 18	30	----------	May 18	30	----------	May 18	30
----------	May 18	30	----------	May 18	70	----------	May 18	20
----------	May 18	40	----------	May 18	40	----------	May 18	30

TABLE 1.—*Bleeding time in normal birds (before inoculation with malaria)*—Continued.

Bird No.	Bleeding time.		Bird No.	Bleeding time.		Bird No.	Bleeding time.	
	Date.	Seconds.		Date.	Seconds.		Date.	Seconds.
	1931			1931			1932	
----------	May 18	60	N48	Aug. 9	60	S17	Jan. 2	40
----------	May 18	50	N49	Aug. 9	70	S18	Jan. 2	40
----------	May 18	40	N62	Aug. 19	40	S19	Jan. 2	50
----------	May 18	40	N63	Aug. 19	60	S20	Jan 2	40
N10	June 26	40	N64	Aug. 19	40	S21	Jan. 2	60
N11	June 26	80	N65	Aug. 19	40	S22	Jan. 2	40
N12	June 26	40	N66	Aug. 19	50	S23	Jan. 2	40
N13	June 26	60	N67	Aug. 19	70	S16	Jan. 18	30
N14	June 26	50	N68	Aug. 24	50	S17	Jan. 18	50
N15	June 26	40	N69	Aug. 24	20	S18	Jan. 18	40
N10	June 27	20	N70	Aug. 24	40	S19	Jan. 18	30
N11	June 27	40	N71	Aug. 24	40	S20	Jan. 18	30
N12	June 27	30	N72	Aug. 24	30	S21	Jan. 18	40
N13	June 27	50	N80	Oct. 16	60	S22	Jan. 18	40
N14	June 27	30	N81	Oct. 16	60	S23	Jan. 18	50
N15	June 27	40	N82	Oct. 16	30	S24	Jan. 22	40
N16	[a]July 3	40	N83	Oct. 16	40	S25	Jan. 22	60
N17	July 3	50	N84	Oct. 16	50	S26	Jan. 22	60
N18	July 3	40	N85	Oct. 16	50	S27	Jan. 22	40
N19	July 3	20	N86	Oct. 16	50	S22	Feb. 4	50
N20	July 3	50	N87	Oct. 16	50	S23	Feb. 4	50
N21	July 3	30	N88	Oct. 16	40	S22	Feb. 5	70
N16	[a]July 4	40	N89	Oct. 16	60	S23	Feb. 5	60
N17	July 4	30	N90	Oct. 16	60	S22	Feb. 6	60
N18	July 4	20	N91	Oct. 16	60	S23	Feb. 6	50
N19	July 4	30	N53	Nov. 3	40	S22	Feb. 8	50
N20	July 4	40	N55	Nov. 3	30	S23	Feb. 8	40
N21	July 4	20	N56	Nov. 3	40	S22	Feb. 9	30
N28	July 23	40	N57	Nov. 3	40	S23	Feb. 9	30
N29	July 23	20	Y28	Sept. 2	40	S22	Feb. 10	40
N30	July 23	60	Y29	Sept. 2	30	S23	Feb. 10	40
N31	July 23	30	Y30	Sept. 2	30	S23	Feb. 13	30
N32	July 23	30	Y31	Sept. 2	50	S20	Jan. 12	70
N33	July 23	20	Y33	Sept. 2	40	S23	Jan. 12	40
N40	Aug. 4	30	Y 3	Oct. 13	20	S20	Jan. 12	30
N41	Aug. 4	40	Y65	Oct. 26	40	S23	Jan. 12	70
N42	Aug. 4	50	Y66	Oct. 26	30	S16	Jan. 16	40
N43	Aug. 4	40	Y67	Oct. 26	40	S17	Jan. 16	40
N44	Aug. 4	40	Y68	Oct. 26	30	S19	Jan. 16	30
N45	Aug. 4	60	Y63	Oct. 26	40	S20	Jan. 16	40
N50	Aug. 7	40	Y64	Oct. 26	60	S21	Jan. 16	50
N51	Aug. 7	30		1932		S22	Jan. 16	50
N52	Aug. 7	70	S15	Jan. 2	30	S23	Jan. 16	30
N47	Aug. 9	70	S16	Jan. 2	30			

[a] 10.50 a. m. [b] 8.45 a. m.

TABLE 2.—*Bleeding time in avian malaria five days after inoculation.*

[Average time 53.6 seconds, in 11 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
N-53	Nov. 9, 1931	40	0	Nov. 4
N-55	Nov. 9, 1931	130	0	Nov. 4
N-56	Nov. 9, 1931	50	0	Nov. 4
N-57	Nov. 9, 1931	40	0	Nov. 4
N-58	Nov. 9, 1931	40	0	Nov. 4
Y-47	Sept. 22, 1931	60	+	Sept. 17
Y-48	Sept. 22, 1931	70	+	Sept. 17
Y-49	Sept. 22, 1931	50	++	Sept. 17
Y-51	Sept. 22, 1931	30	+	Sept. 17
S-20	Feb. 4, 1932	40	+	Jan. 30
S-21	Feb. 4, 1932	40	+	Jan. 30

TABLE 3.—*Bleeding time in acute avian malaria six days after inoculation.*

[Average time 83.9 seconds, in 28 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
L-94	June 19, 1931	60	+	June 13
L-97	June 19, 1931	60	+	June 13
L-96	June 19, 1931	40	+	June 13
L-96	June 19, 1931	60	+	June 13
L-91	June 16, 1931	170	0	June 10
L-87	June 16, 1931	160	0	June 10
N-16	July 12, 1931	100	++	July 6
N-17	July 12, 1931	70	++++	July 6
N-18	July 12, 1931	100	++	July 6
N-19	July 12, 1931	70	++++	July 6
N-21	July 12, 1931	60	+	July 6
N-62	Aug. 27, 1931	100	+	Aug. 21
N-63	Aug. 27, 1931	70	+	Aug. 21
N-64	Aug. 27, 1931	80	+	Aug. 21
N-65	Aug. 27, 1931	70	+++++	Aug. 21
N-66	Aug. 27, 1931	90	++++	Aug. 21
N-67	Aug. 27, 1931	120	++	Aug. 21
Y-35	Sept. 18, 1931	80	++++	Sept. 12
Y-41	Sept. 18, 1931	100	+	Sept. 12
Y-42	Sept. 18, 1931	140	++	Sept. 12
Y-44	Sept. 18, 1931	80	+	Sept. 12
Y-64	Nov. 2, 1931	70	+	Oct. 27
Y-65	Nov. 2, 1931	40	+	Oct. 27
Y-66	Nov. 2, 1931	100	+	Oct. 27
Y-67	Nov. 2, 1931	80	+	Oct. 27
Y-68	Nov. 2, 1931	90	+	Oct. 27
S-20	Feb. 5, 1932	40	+	Jan. 30
S-21	Feb. 5, 1932	50	+	Jan. 30

TABLE 4.—*Bleeding time in acute avian malaria seven days after inoculation.*

[Average time 98.9 seconds, in 18 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
N-10	July 6, 1931	100	++	June 29
N-11	July 6, 1931	120	++	June 29
N-12	July 6, 1931	180	++++	June 29
N-14	July 6, 1931	140	++++	June 29
N-15	July 6, 1931	90	++++	June 29
N-19	July 13, 1931	90	+++++	July 6
N-21	July 13, 1931	90	++++	July 6
N-16	July 13, 1931	230	++++	July 6
N-17	July 13, 1931	100	+++++	July 6
N-18	July 13, 1931	210	++++	July 6
N-40	Aug. 14, 1931	80	+++	Aug. 7
N-41	Aug. 14, 1931	50	++++	Aug. 7
N-42	Aug. 14, 1931	130	+++++	Aug. 7
S-16	Jan. 25, 1932	30	0	Jan. 18
S-17	Jan. 25, 1932	30	+	Jan. 18
S-18	Jan. 25, 1932	30	+	Jan. 18
S-20	Feb. 6, 1932	40	+	Jan. 30
S-21	Feb. 6, 1932	40	+	Jan. 30

TABLE 5.—*Bleeding time in acute avian malaria eight days after inoculation.*

[Average time 118.6 seconds, in 21 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
L-48	May 19, 1931	70	+	May 11
N-10	July 7, 1931	110	+++	June 29
N-11	July 7, 1931	290	++	June 29
N-12	July 7, 1931	90	+++	June 29
N-14	July 7, 1931	360	++++	June 29
N-15	July 7, 1931	100	++++	June 29
N-43	Aug. 15, 1931	170	++++	Aug. 7
N-46	Aug. 15, 1931	150	++++	Aug. 7
N-47	Aug. 18, 1931	80	+++++	Aug. 10
N-48	Aug. 18, 1931	140	+++++	Aug. 10
N-49	Aug. 18, 1931	70	+++++	Aug. 10
N-50	Aug. 18, 1931	110	+++++	Aug. 10
N-51	Aug. 18, 1931	150	+++++	Aug. 10
N-52	Aug. 18, 1931	100	++	Aug. 10
Y-28	Sept. 15, 1931	80	+++++	Sept. 7
Y-29	Sept. 15, 1931	30	++++	Sept. 7
Y-30	Sept. 15, 1931	70	0	Sept. 7
Y-33	Sept. 15, 1931	130	+++++	Sept. 7
S-16	Jan. 26, 1932	70	+	Jan. 18
S-17	Jan. 26, 1932	60	+	Jan. 18
S-18	Jan. 26, 1932	60	+	Jan. 18

TABLE 6.—*Bleeding time in acute avian malaria nine days after inoculation.*

[Average time 84.4 seconds, in 18 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
L-46	May 20, 1931	90	+	May 11
L-48	May 20, 1931	100	+	May 11
L-89	June 19, 1931	100	+++	June 10
L-92	June 19, 1931	90	++++	June 10
L-93	June 19, 1931	90	+	June 10
L-90	June 19, 1931	100	++++	June 10
N- 1	June 26, 1931	70	+++++	June 17
N- 2	June 26, 1931	110	++++	June 17
N-15	July 8, 1931	60	+++++	June 29
N-29	Aug. 3, 1931	140	+++	July 25
N-31	Aug. 3, 1931	60	+++++	July 25
N-33	Aug. 3, 1931	60	+++++	July 25
D-87	Jan. 8, 1932	50	+	Dec. 30
S-16	Jan. 27, 1932	80	+	Jan. 18
S-17	Jan. 27, 1932	50	+	Jan. 18
S-18	Jan. 27, 1932	110	++	Jan. 18
S-20	Feb. 8, 1932	120	++++	Jan. 30
S-21	Feb. 8, 1932	40	+++++	Jan. 30

RESULTS

In a series of one hundred eighty tests in normal birds the average bleeding time was found to be 42.4 ± 10 seconds and this may be taken as the usual bleeding time in canaries. (See Table 1.)

TABLE 7.—*Bleeding time in acute avian malaria ten days after inoculation.*

[Average time 76.4 seconds, in 28 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
L-48	May 21, 1931	150	+	May 11
N-15	July 9, 1931	40	+++++	June 29
N-40	Aug. 17, 1931	110	+++++	Aug. 7
N-41	Aug. 17, 1931	150	+++++	Aug. 7
N-43	Aug. 17, 1931	60	+++++	Aug. 7
N-46	Aug. 17, 1931	60	+++++	Aug. 7
N-80	Oct. 27, 1931	50	+	Oct. 17
N-82	Oct. 27, 1931	30	+	Oct. 17
N-83	Oct. 27, 1931	100	+	Oct. 17
N-86	Oct. 27, 1931	120	+	Oct. 17
N-89	Oct. 27, 1931	70	+	Oct. 17
N-90	Oct. 27, 1931	90	+	Oct. 17
N-91	Oct. 27, 1931	110	+	Oct. 17
Y-16	Aug. 27, 1931	90	++	Aug. 17
Y-20	Aug. 27, 1931	110	++++	Aug. 17
Y-23	Aug. 27, 1931	80	+	Aug. 17
Y-24	Aug. 27, 1931	90	+	Aug. 17
Y-25	Aug. 27, 1931	90	+	Aug. 17
Y-35	Sept. 22, 1931	30	+	Sept. 12
Y-41	Sept. 22, 1931	40	+	Sept. 12
Y-42	Sept. 22, 1931	50	++	Sept 12
Y-44	Sept. 22, 1931	90	+	Sept. 12
Y-46	Sept. 22, 1931	50	0	Sept. 12
S-16	Jan. 28, 1932	40	+	Jan. 18
S-17	Jan. 28, 1932	60	++	Jan. 18
S-18	Jan. 28, 1932	60	++++	Jan. 18
S-20	Feb. 9, 1932	70	+++++	Jan. 30
S-21	Feb. 9, 1932	50	+++++	Jan. 30

TABLE 8.—*Bleeding time in acute avian malaria eleven days after inoculation.*

[Average time 61.8 seconds, in 17 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Date of inoculation.
		Sec.		
L-40	May 19, 1931	60	+	May 8
L-54	May 29, 1931	60	++++	May 18
L-57	May 29, 1931	60	++++	May 18
L-52	May 29, 1931	100	+++++	May 18
L-56	May 29, 1931	50	+	May 18
L-55	May 29, 1931	40	++++	May 18
L-53	May 29, 1931	60	++++	May 18
N-15	July 10, 1931	20	+++++	June 29
N-17	July 17, 1931	50	+++++	July 6
Y-29	Sept. 18, 1931	50	+++++	Sept. 7
Y-30	Sept. 18, 1931	150	0	Sept. 7
Y-33	Sept. 18, 1931	20	+++++	Sept. 7
S-16	Jan. 29, 1932	30	++	Jan. 18
S-17	Jan. 29, 1932	70	+++	Jan. 18
S-18	Jan. 29, 1932	60	+++++	Jan. 18
S-20	Feb. 10, 1932	110	++++	Jan. 30
S-21	Feb. 10, 1932	60	+++++	Jan. 30

TABLE 9.—*Bleeding time in acute avian malaria twelve days after inoculation.*

[Average time 68 seconds, in 10 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear or bleeding time date.	Date of inoculation.
		Sec.		
L-42	May 20, 1931	70	+++	May 8
L-59	Aug. 26, 1931	60	++++	Aug. 14
L-59	Aug. 26, 1931	120	++++	Aug. 14
N-15	July 11, 1931	50	+++++	June 29
N-17	July 18, 1931	40	+++++	July 6
X-66	Aug. 26, 1931	50	++++	Aug. 14
X-99	Aug. 26, 1931	90	+++	Aug. 14
X-66	Aug. 26, 1931	40	++++	Aug. 14
X-99	Aug. 26, 1931	70	+++	Aug. 14
S-16	Jan. 30, 1932	50	+++++	Jan. 18

TABLE 10.—*Bleeding time in subacute avian malaria thirteen to twenty days after inoculation.*

[Average time 62.9 seconds, in 35 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear on bleeding time date.	Inoculation.	Days from inoculation to bleeding date.
		Sec.			
L-35	May 18, 1931	60	+	May 4	14
L-39	May 18, 1931	30	++	May 4	14
L-37	May 18, 1931	30	+	May 4	14
L-35	May 19, 1931	60	+	May 4	15
L-36	May 19, 1931	50	++	May 4	15
L-39	May 19, 1931	40	++	May 4	15
L-37	May 19, 1931	50	+	May 4	15
L-36	May 21, 1931	50	+++	May 4	17
L-40	May 21, 1931	50	+	May 8	13
L-50	May 29, 1931	60	++++	May 15	14
L-46	May 29, 1931	60	+++++	May 11	18
L-46	May 29, 1931	70	+++++	May 11	18
L-83	June 19, 1931	70	+++++	June 6	13
L-84	June 19, 1931	80	+	June 6	13
N-17	July 19, 1931	70	+++++	July 6	13
N-17	July 20, 1931	60	+++++	July 6	14
N-21	July 21, 1931	50	+++++	July 6	15
N-80	Oct. 31, 1931	70	++++	Oct. 17	14
N-82	Oct. 31, 1931	70	++++	Oct. 17	14
N-83	Oct. 31, 1931	50	+++++	Oct. 17	14
N-85	Oct. 31, 1931	100	0	Oct. 17	14
N-89	Oct. 31, 1931	50	+++++	Oct. 17	14
N-90	Oct. 31, 1931	100	++++	Oct. 17	14
N-91	Oct. 31, 1931	90	+++++	Oct. 17	14
Y-16	Sept. 3, 1931	40	++	Aug. 17	17
Y-19	Sept. 3, 1931	70	+++++	Aug. 17	17
Y-22	Sept. 3, 1931	40	+	Aug. 17	17
Y-23	Sept. 3, 1931	20	++	Aug. 17	17
Y-24	Sept. 4, 1931	110	++++	Aug. 17	18
Y-25	Sept. 4, 1931	50	0	Aug. 17	18
D-71	Jan 8, 1932	60	++++	Dec. 22	17
D-72	Jan. 8, 1932	90	++++	Dec. 22	17
D-74	Jan. 8, 1932	130	+++++	Dec. 22	17
S-20	Feb. 13, 1932	40	+	Jan. 30	14
S-21	Feb. 13, 1932	80	++++	Jan. 30	14

TABLE 11.—*Bleeding time in chronic avian malaria twenty-one or more days after inoculation.*

[Average time 32.7 seconds, in 113 tests.]

Bird No.	Date of bleeding.	Bleeding time.	Blood smear or bleeding time date.	Inoculation.	Days from inoculation to bleeding date.
		Sec.			
L-20	May 18, 1931	40	+	April 25	23
L-22	May 18, 1931	40	+	April 25	23
L-22	May 19, 1931	50	+	April 25	24
L-21	May 19, 1931	120	+	April 25	24
L-25	May 19, 1931	70	+	April 28	21
L-21	May 20, 1931	60	+	April 25	25
L-14	June 17, 1931	30	0	April 20	58
L-9	June 17, 1931	30	0	April 13	65
L-25	June 17, 1931	40	0	April 2	76
L-39	June 17, 1931	30	0	May 4	44
L-11	June 17, 1931	60	0	April 18	60
L-50	June 17, 1931	20	0	May 15	33
L-20	June 17, 1931	20	+	April 25	53
L-27	June 17, 1931	30	0	April 28	50
L-22	June 17, 1931	30	+	April 25	53
L-58	June 17, 1931	30	0	May 14	34
L-20	June 17, 1931	20	+	April 25	53
L-14	Aug. 20, 1931	40	0	April 20	122
L-25	Aug. 20, 1931	20	0	April 28	114
L-27	Aug. 20, 1931	30	0	April 28	114
L-35	Aug. 20, 1931	30	0	May 4	108
L-40	Aug. 20, 1931	20	0	May 4	108
L-48	Aug. 20, 1931	30	0	May 11	101
L-14	Sept. 15, 1931	30	0	April 20	148
L-22	Sept. 15, 1931	20	0	April 25	143
L-25	Sept. 15, 1931	20	0	April 28	140
L-27	Sept. 15, 1931	40	0	April 28	140
L-35	Sept. 15, 1931	40	0	May 4	134
L-39	Sept. 15, 1931	30	0	May 4	134
L-40	Sept. 15, 1931	30	0	May 8	130
L-48	Sept. 15, 1931	30	0	May 11	127
L-57	Sept. 15, 1931	20	0	May 18	120
L-76	Sept. 15, 1931	30	0	June 1	106
L-92	Sept. 15, 1931	40	0	June 10	97
L-94	Sept. 15, 1931	30	0	June 13	94
J-16	May 29, 1931	40	0	Aug. 26, 1930	276
J-54	May 29, 1931	50	0	Nov. 15, 1930	195
J-44	May 29, 1931	30	0	Sept. 13, 1930	254
J-52	May 29, 1931	50	0	Nov. 1, 1930	209
J-51	May 29, 1931	30	0	Nov. 1, 1930	209
J-21	May 29, 1931	50	0	Aug. 27, 1930	275
J-27	May 29, 1931	30	0	Aug. 29, 1930	273
J-50	May 29, 1931	20	0	Oct. 14, 1930	227
J-42	May 29, 1931	30	0	Sept. 15, 1930	256
J-46	May 29, 1931	30	0	Oct. 2, 1930	239
J-28	May 29, 1931	40	0	Aug. 29, 1930	273
J-49	May 29, 1931	30	0	Oct. 14, 1930	227
J-51	May 29, 1931	60	0	Nov. 1, 1930	209

TABLE 11.—*Bleeding time in chronic avian malaria twenty-one or more days after inoculation*—Continued.

Bird No.	Date of bleeding.	Bleeding time.	Blood smear or bleeding time date.	Inoculation.	Days from inoculation to bleeding date.
		Sec.			
J-27	May 29, 1931	30	0	Aug. 27, 1930	275
J-50	May 29, 1931	20	0	Oct. 14, 1930	227
J-42	May 29, 1931	30	0	Sept. 15, 1930	256
J-46	May 29, 1931	30	0	Oct. 2, 1930	239
N-73	Nov. 3, 1931	30	0	September 23	42
N-74	Nov 3, 1931	50	0	September 23	42
N-75	Nov. 3, 1931	70	0	September 23	42
N-76	Nov. 3, 1931	70	0	September 23	42
N-73	Nov. 9, 1931	40	0	September 23	47
N-74	Nov. 9, 1931	80	0	September 23	47
N-48	Oct. 15, 1931	90	0	August 10	66
N-60	Oct. 15, 1931	90	+	August 14	62
N-61	Oct. 15, 1931	100	0	August 20	56
Y-11	Oct. 13, 1931	30	0	August 28	46
Y-12	Oct. 13, 1931	30	+	August 28	46
Y-14	Oct. 13, 1931	40	0	August 25	49
Y-16	Oct. 13, 1931	40	0	August 17	57
Y-22	Oct. 13, 1931	30	+	August 17	57
Y-23	Oct. 13, 1931	40	+	August 17	57
Y-24	Oct. 13, 1931	40	0	August 17	57
Y-25	Oct. 13, 1931	40	+	August 17	57
Y-35	Oct. 13, 1931	30	+	September 12	31
Y-41	Oct. 13, 1931	40	0	September 12	31
Y-42	Oct. 13, 1931	40	0	September 12	31
Y-44	Oct. 15, 1931	50	0	September 12	33
Y-48	Oct. 15, 1931	20	0	September 17	28
Y-49	Oct. 15, 1931	30	+	September 17	28
Y-51	Oct. 15, 1931	50	+	September 17	28
Y-57	Oct. 15, 1931	20	+++++	September 22	23
Y-58	Oct. 15, 1931	40	+	September 22	23
Y-59	Oct. 15, 1931	30	+	September 22	23
Y-70	Oct. 26, 1931	60	0	September 22	34
Y-72	Oct. 26, 1931	40	0	September 22	34
Y-46	Oct. 26, 1931	80	0	September 12	44
Y-60	Oct. 26, 1931	30	0	September 5	41
Y-61	Oct. 26, 1931	50	0	September 5	41
Y-73	Oct. 26, 1931	50	0	September 22	34
Y-74	Oct. 26, 1931	60	0	September 22	34
Y-76	Oct. 26, 1931	70	0	September 22	34
Y-77	Oct. 30, 1931	50	0	September 22	38
Y-79	Oct. 30, 1931	20	0	September 22	38
Y-80	Oct. 30, 1931	40	0	September 22	38
Y-60	Nov. 2, 1931	50	+	September 5	58
Y-61	Nov. 2, 1931	50	+	September 5	58
Y-70	Nov. 2, 1931	50	+	September 22	41
Y-72	Nov. 2, 1931	60	+	September 22	41
Y-73	Nov. 2, 1931	60	++	September 22	41
Y-74	Nov. 2, 1931	70	+	September 22	41
Y-76	Nov. 2, 1931	40	+	September 22	41
Y-77	Nov. 4, 1931	50	0	September 22	41

TABLE 11.—*Bleeding time in chronic avian malaria twenty-one or more days after inoculation*—Continued.

Bird No.	Date of bleeding.	Bleeding time.	Blood smear or bleeding time date.	Inoculation.	Days from inoculation to bleeding date.
		Sec.			
Y-79	Nov. 4, 1931	40	0	September 22	41
Y-80	Nov. 4, 1931	50	0	September 22	41
Y-77	Nov. 7, 1931	70	+	September 22	46
Y-79	Nov. 7, 1931	70	+	September 22	46
Y-80	Nov. 7, 1931	60	+	September 22	46
D-34	Jan. 8, 1932	40	+	December 3	36
V-100	June 17, 1931	40	0	Sept. 24, 1930	266
V-97	June 17, 1931	30		Sept. 1, 1930	289
V-41	May 29, 1931	40		July 12, 1930	321
V-41	May 29, 1931	30		July 12, 1930	321
V-49	May 29, 1931	40		July 18, 1930	315
V-100	May 29, 1931	30		July 18, 1930	315
V-95	June 17, 1931	50	0	Sept. 24, 1930	266
V-41	June 17, 1931	40		July 12, 1930	340
V-81	June 3, 1931	30		Aug. 11, 1930	310

A series of two hundred ninety-five tests were made in birds having malaria. These tests have been divided, as shown in Tables 2 to 11, into groups with bleeding times as follows:

Day following inoculation that bird was bled.	Average bleeding time. Sec.
Fifth	53.6
Sixth	83.9
Seventh	98.9
Eighth	118.6
Ninth	84.4
Tenth	76.4
Eleventh	61.8
Twelveth	64.0
Thirteenth	62.9
Twenty-first or later	32.7

(See graph)

These tests may also be grouped more generally as in Table 12.

TABLE 12.—*Bleeding time grouped according to status of the infection with normal figure for comparison.*

Status of infection.	Days after inoculation.	Number of tests.	Total bleeding time.	Average bleeding time.
			Sec.	*Sec.*
Normal bird, not infected		180	7,630	42.4 (+10.4)
Acute	5-8	78	7,210	92.4
Subacute	9-20	104	7,550	72.6
Chronic	21 or more	113	3,700	32.7

TABLE 13.—*Bleeding times before and after inoculation. Avian malaria.*

Bird No.	Bleeding time before inoculation.			Bleeding times in seconds grouped by number of days after inoculation.								
	First reading.	Second reading.	Average.	6	7	8	9	10	11	12	13	14
N-10	40	20	30	------	100	110	------	------	----	----	----	------
N-11	80	40	60	------	120	290	------	------	----	----	----	------
N-12	40	30	35	------	180	90	------	------	----	----	----	------
N-13	60	50	55	------	------	------	------	------	----	----	----	------
N-14	50	30	40	------	140	360	------	------	----	----	----	------
N-15	40	40	40	------	90	100	60	40	20	50	----	------
N-16	40	40	40	100	230	------	------	------	----	----	----	------
N-17	50	30	40	70	100	------	------	------	50	40	70	[a] 60
N-18	40	20	30	100	210	------	------	------	----	----	----	------
N-19	20	30	25	70	90	------	------	------	----	----	----	------
N-20	50	40	45	------	------	------	------	------	----	----	----	------
N-21	30	20	25	60	90	------	------	------	----	----	----	------
N-29	20	------	20	------	------	------	140	------	----	----	----	------
N-31	30	------	30	------	------	------	60	------	----	----	----	------
N-33	20	------	20	------	------	------	60	------	----	----	----	------
N-40	30	------	30	------	80	------	------	110	----	----	----	------
N-41	40	------	40	------	50	------	------	150	----	----	----	------
N-42	50	------	50	------	130	------	------	------	----	----	----	------
N-43	40	------	40	------	------	170	------	60	----	----	----	------
N-46	40	------	40	------	------	150	------	60	----	----	----	------
N-47	70	------	70	------	------	80	------	------	----	----	----	------
N-48	60	------	60	------	------	140	------	------	----	----	----	------
N-49	70	------	70	------	------	70	------	------	----	----	----	------
N-50	40	------	40	------	------	110	------	------	----	----	----	------
N-51	30	------	30	------	------	150	------	------	----	----	----	------
N-52	70	------	70	------	------	100	------	------	----	----	----	------
N-62	40	------	40	100	------	------	------	------	----	----	----	------
N-63	60	------	60	70	------	------	------	------	----	----	----	------
N-64	40	------	40	80	------	------	------	------	----	----	----	------
N-65	40	------	40	70	------	------	------	------	----	----	----	------
N-66	50	------	50	90	------	------	------	------	----	----	----	------
N-67	70	------	70	120	------	------	------	------	----	----	----	------
N-80	60	------	60	------	------	------	------	50	----	----	----	70
N-82	30	------	30	------	------	------	------	30	----	----	----	70
N-83	40	------	40	------	------	------	------	100	----	----	----	50
N-85	50	------	50	------	------	------	------	------	----	----	----	100
N-86	50	------	50	------	------	------	------	120	----	----	----	------
N-89	60	------	60	------	------	------	------	70	----	----	----	50
N-90	60	------	60	------	------	------	------	90	----	----	----	100
N-91	60	------	60	------	------	------	------	110	----	----	----	90
Total	------	------	1,785	930	1,610	1,920	------	990	----	----	----	590
Average	------	------	44.6	84.5	123.8	147.7	------	82.5	----	----	----	73.8

[a] On the fifteenth day the bleeding time was fifty seconds.

In forty cases birds which were bled before inoculation were also bled again one or more times after inoculation. The results in these cases have been grouped in Table 13. It is again evident that there is a rise in the curve of the bleeding time in acute malaria from a normal of approximately forty to fifty seconds to a high on the eighth day of two minutes or more, after which the bleeding time tends to become shorter. These results in Table 13 may also be grouped as in Table 14:

TABLE 14.—*Bleeding times taken before and after inoculation. Avian malaria.*

Status of infection.	Days after inoculation	Number of tests.	Total of bleeding time.	Average bleeding time.
			Sec.	*Sec.*
Normal bird, not infected	----------	40	1,785	44.6
Acute	5- 8	37	4,460	120.5
Subacute	9-20	30	2,180	72.7

Table 14 resembles Table 12 in the same way that Table 13 gives similar results to those in Tables 2 to 11.

In fifty-seven instances on the same morning that bleeding times were taken a red-blood-cell count was made. The results of these tests are shown in Table 15. Generally speaking it appears that the shorter the bleeding time the higher the red-blood-cell count and vice versa.

We may also group these results more generally as in Table 16.

There are too few tests in the subacute and chronic groups to permit any conclusions. But with twenty eight birds counted in the normal group it is likely that the normal red-cell count for canaries purchased in Manila is about 3,350,000. The birds as a rule are somewhat undernourished at first, so that this count may be slightly lower than normal. The pipettes were calibrated and all counts were done by one microscopist.

There is a decrease in red cells in malaria and this decrease coincides with the increased bleeding time but is not necessarily a cause of that increase.

An attempt was made to get some information regarding the calcium content of the blood at the same time the bleeding time was being measured. In Tables 17 and 18 are given some results which must be regarded as preliminary in view of the small amount of blood, usually not more than 0.5 cubic centimeter, available for testing. I am indebted to Maj. Rufus L. Holt, of the Medical Department Research Board, United States Army, at the Bureau of Science, for the calcium determinations.

TABLE 15.—*Bleeding times and red-blood-cell counts determined in the same birds at the same time.*

Bird.	Date.	[a] R. B. C.
Bleeding time, 10 to 30 seconds.		
	1931	
N29	July 23	366
N31	July 23	353
N32	July 23	394
N33	July 23	381
N40	Aug. 4	363
N51	Aug. 7	290
N69	Aug. 24	289
N72	Aug. 24	239
L14	Sept. 15	395
L22	Sept. 15	454
L25	Sept. 15	285
L57	Sept. 15	264
Total	----------	4,073
Average	----------	339
Bleeding time, 40 to 60 seconds.		
N28	July 23	361
N30	July 23	387
N31	Aug. 3	172
N33	Aug. 3	116
N41	Aug. 4	374
N42	Aug. 4	348
N43	Aug. 4	405
N44	Aug. 4	450
	1931	
N45	Aug. 4	340
N50	Aug. 7	388
N48	Aug. 9	298
N41	Aug. 14	156
N43	Aug. 17	141
N46	Aug. 17	172
N62	Aug. 19	310
N63	Aug. 19	329
N64	Aug. 19	182
N65	Aug. 19	267
N66	Aug. 19	245
N68	Aug. 24	385
N71	Aug. 24	184
L27	Sept. 15	311
L92	Sept. 15	422
Total	----------	6,733
Average	----------	293
Bleeding time, 70 to 110 seconds.		
N52	Aug. 7	278
N47	Aug. 9	370
N49	Aug. 9	353
N40	Aug. 14	250
N40	Aug. 17	226
	1931	
N47	Aug. 18	154
N49	Aug. 18	137
N50	Aug. 18	133
N52	Aug. 18	167
N67	Aug. 19	362
N62	Aug. 27	164
N63	Aug. 27	183
N64	Aug. 27	129
N65	Aug. 27	151
N66	Aug. 27	212
Total	----------	3,269
Average	----------	218
Bleeding time, 120 or more seconds.		
N29	Aug. 3	184
N42	Aug. 14	155
N43	Aug. 15	147
N46	Aug. 15	175
N41	Aug. 17	142
N48	Aug. 18	173
N67	Aug. 27	171
Total	----------	1,147
Average	----------	164

[a] "R. B. C." means red blood cells per cubic millimeter. Four ciphers have been omitted after each of the numbers in this column.

TABLE 16.—*Average bleeding times and red-blood-cell counts in same birds grouped according to status of infection.*

Status of infection.	Days after inoculation.	Number of tests.	Total of bleeding time.	Average red blood-cell count per cubic millimeter.
			Sec.	
Normal bird	------------	28	44.3	3,350,000
Acute	5- 8	16	100.6	1,660,000
Subacute	9-20	7	91.4	1,650,000
Chronic	21 or more	6	28.3	3,550,000

TABLE 17.—*Calcium determination in avian malaria grouped according to status of infection, with normal figures for comparison.*

Status of infection.	Days after inoculation.	Number of tests.	Average calcium content in 100 cubic centimeters blood.
			Mg.
Normal birds	....	52	11.1
Acute	5– 8	26	8.0
Subacute	9–20	25	9.5
Chronic	21 or more.	56	12.5

TABLE 18.—*Calcium determination and bleeding time in avian malaria.*

Bleeding time.	Calcium determinations.		
	Number.	Total.	Average content of 100 cubic centimeters blood.
Sec			*Mg.*
10–30	36	433.67	12.05
40–60	75	805.59	12.74
70–110	44	476.35	10.83
120 or more	9	70.65	7.85

No attempt is made at this time to explain the interesting fact that the bleeding time in acute avian malaria is in many cases considerably longer than normal. It is believed that the method of determining this time is a good one since in one hundred eighty tests on normal birds the standard deviation was only 10 seconds in respect to an average of 42.4 seconds, with 10 seconds the smallest unit of measurement used.

The fact that the standard deviations of the groups in Tables 2 to 11, tested in various stages of infections, were all large is, beyond the 10 second S. D. of the normal group, of no significance as regards method. Therefore, these deviations are due not to breaks in technic but to the biological fact that some birds have a prolonged bleeding time in malaria and others do not. This is shown better in Table 19 where the tests are grouped to indicate what percentage of birds in each group have bleeding times of 100 seconds or more; that is, two or more times the normal. It is seen that in one hundred eighty normal tests none was found to be 100 seconds or more; but after infection, from the fifth to the eighth day, these prolonged bleeding times begin to appear. On the eighth day 52.4 per cent of the birds had a bleeding time of 100 seconds or more. The average of this 52.4 per cent of birds is 164.5 seconds, more than three times normal. Only one bird in twenty one had a normal bleeding time and in two others there was only a slight increase.

One can not look to blood platelets or an explanation of the increased bleeding time since, as already noted, these elements are not found in avian blood. There is perhaps some evidence in Tables 15 and 16 that the increase in bleeding time is related to a decrease in red blood cells, and in Tables 17 and 18 the evidence possibly links bleeding time and blood calcium. But at the best these results are inconclusive and further studies are indicated, which will include an investigation of coagulation time and thrombocyte density.

It is of course interesting, but at present idle, to speculate as to possible relationships between bleeding time, calcium content, malaria, and black-water fever. If the calcium content is lowered in acute malaria, what is the reason and what becomes of the calcium? These and other questions remain to be answered.

TABLE 19.—*Percentage of birds having bleeding times 100 seconds or longer grouped according to status of malaria infection.*

Status of infection. Days after inoculation.	Number of tests.	Bleeding times 100 seconds or longer.	
		Number.	Per cent.
Normal bird (no infection)	180	0	0
5	11	1	9.1
6	28	9	32.1
7	18	8	44.4
8	21	11	52.4
9	18	7	38.9
10	28	7	25.0
11	17	3	17.6
12	10	1	10.0
13–20	35	4	11.4
21 or more	113	2	1.8

SUMMARY

A brief discussion is presented regarding bleeding time.

Experiments are reported which show that the normal bleeding time in birds is 42.4 ± 10 seconds. The bleeding time in acute avian malaria has been found to be frequently longer than in normal birds. This prolonged bleeding time coincides with, but is not necessarily caused by, a decrease in the number of red blood cells and apparently a decrease in the calcium content of the blood.

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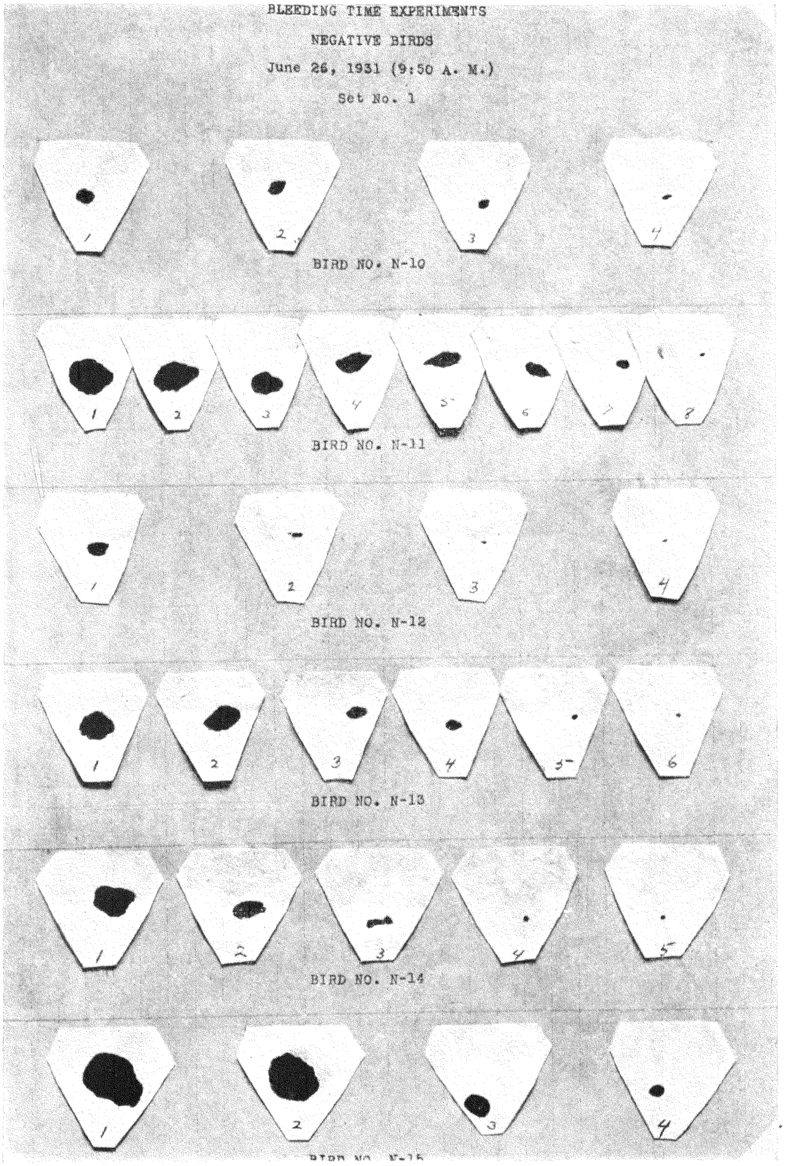
ILLUSTRATIONS

PLATE 1. Normal bleeding time in avian malaria; set 1.
2. Normal bleeding time in avian malaria; set 2.
3. Bleeding time in acute avian malaria; set 1.
4. Bleeding time in acute avian malaria; set 2.
5. Bleeding time in chronic avian malaria.

TEXT FIGURE

FIG. 1. Graph showing bleeding time in seconds in groups of birds, normal and at varying periods after inoculations. (See Tables 1 to 11.)



BLEEDING TIME EXPERIMENTS

NEGATIVE BIRDS

June 26, 1931 (9:50 A. M.)

Set No. 1

BIRD NO. N-10

BIRD NO. N-11

BIRD NO. N-12

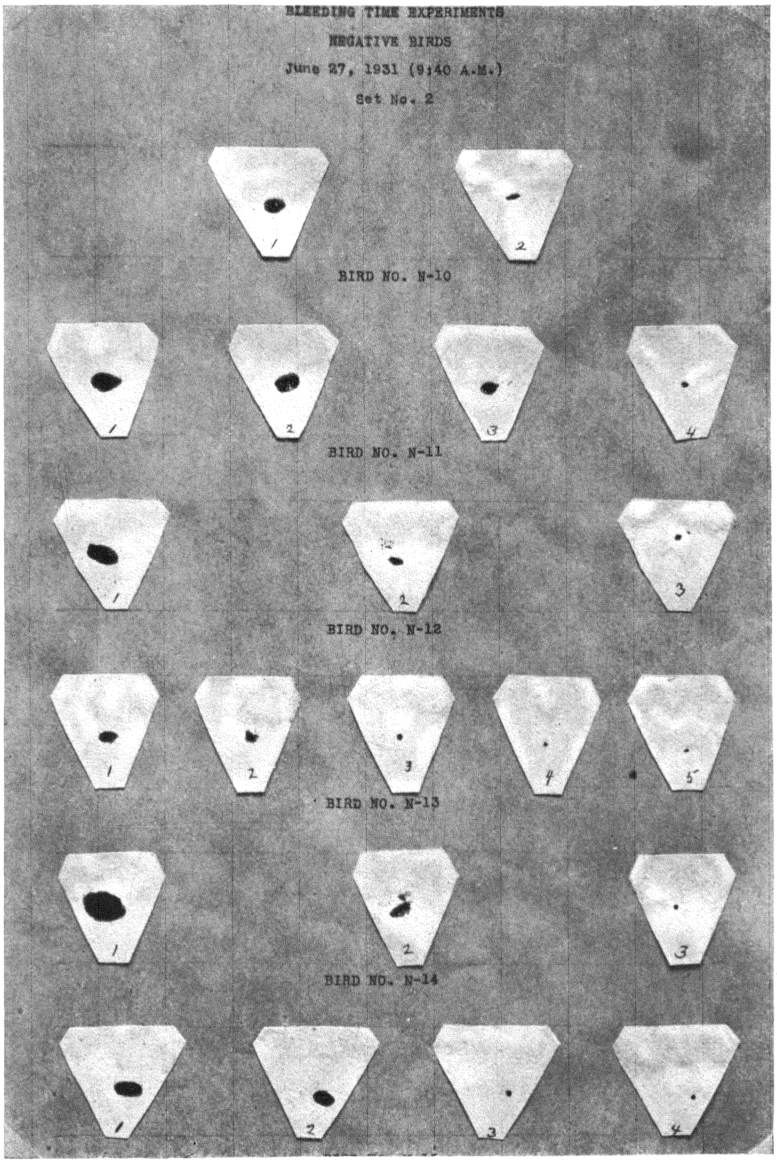
BIRD NO. N-13

BIRD NO. N-14

BIRD NO. N-15

PLATE 1. NORMAL BLEEDING TIME IN AVIAN MALARIA; SET 1.

UNIV. OF MICH.



BLEEDING TIME EXPERIMENTS

NEGATIVE BIRDS

June 27, 1931 (9:40 A.M.)

Set No. 2

BIRD NO. N-10

BIRD NO. N-11

BIRD NO. N-12

BIRD NO. N-13

BIRD NO. N-14

PLATE 2. NORMAL BLEEDING TIME IN AVIAN MALARIA; SET 2.

UNIV. OF MICH.

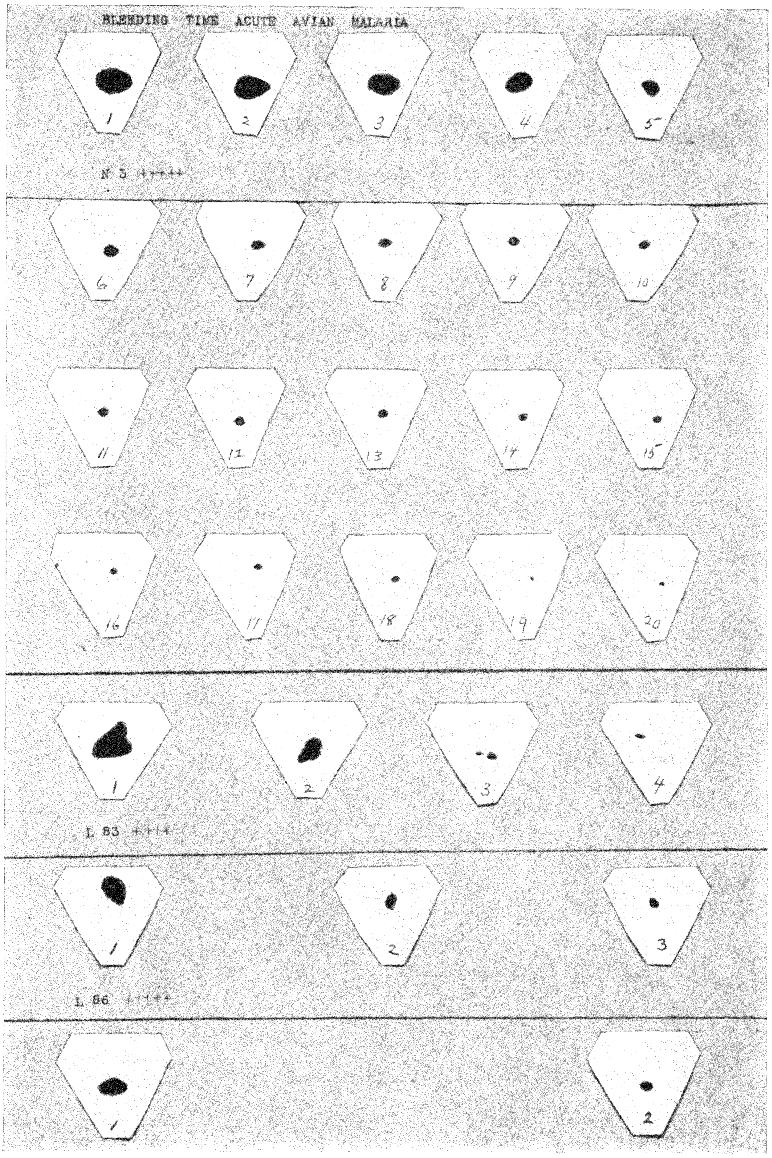


PLATE 3. BLEEDING TIME IN ACUTE AVIAN MALARIA; SET 1.

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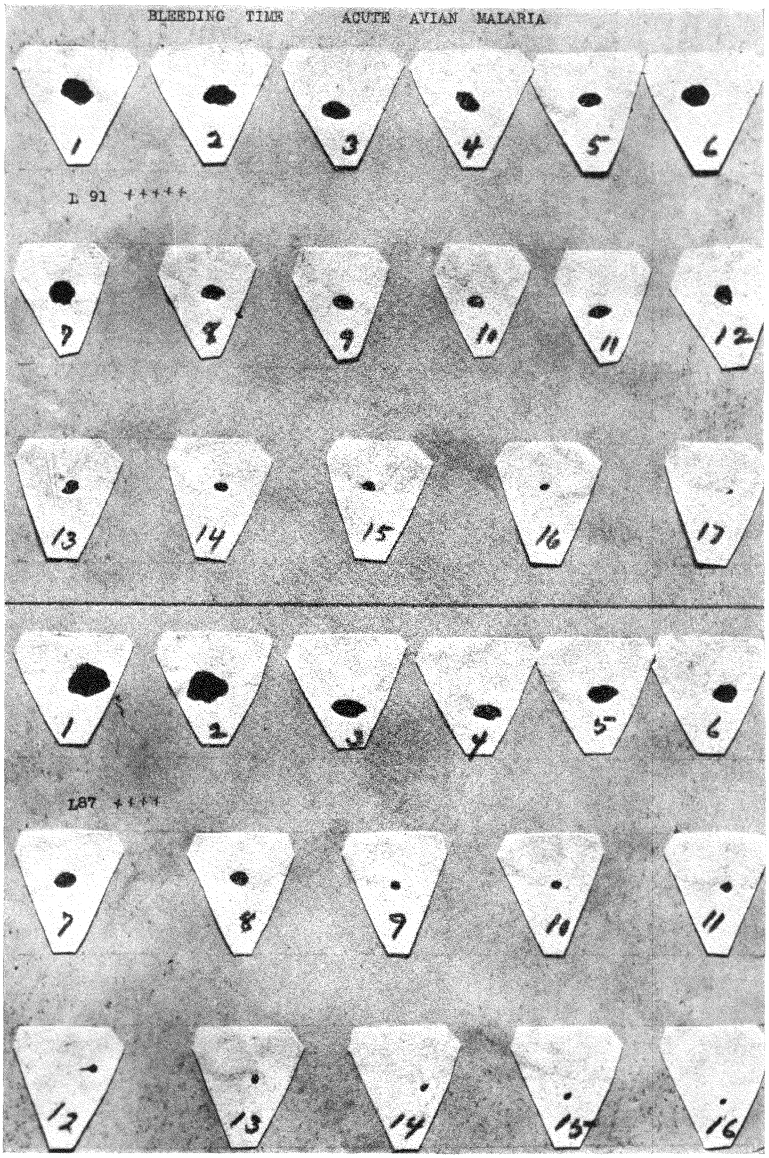

PLATE 4. BLEEDING TIME IN ACUTE AVIAN MALARIA; SET 2.

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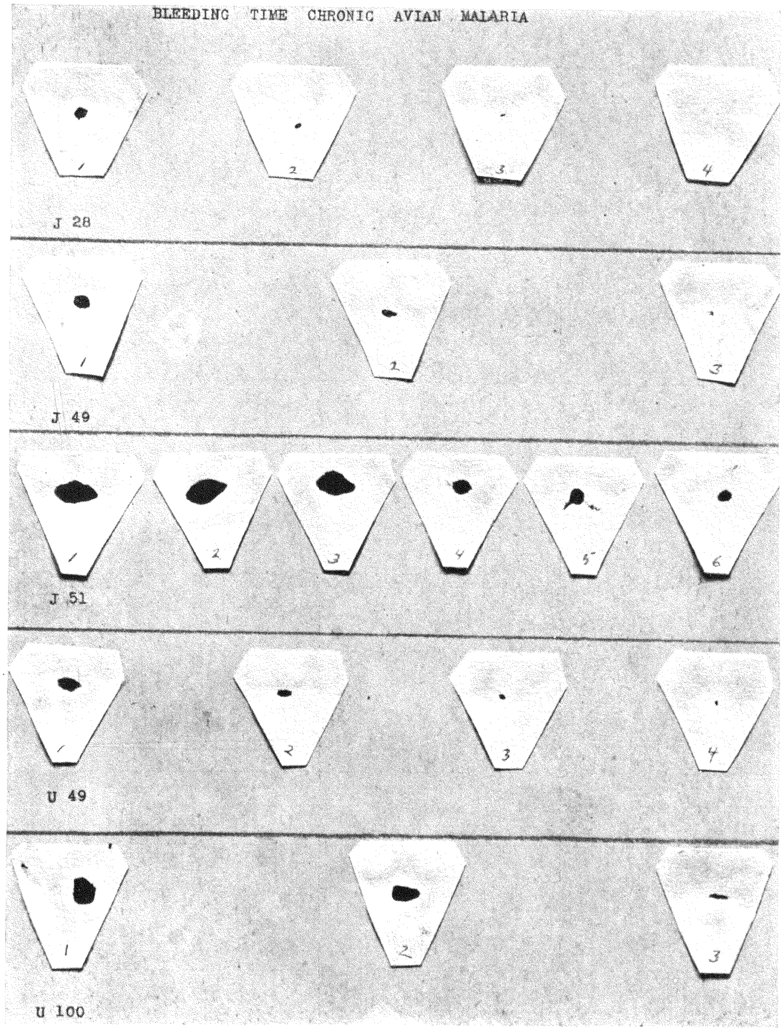

PLATE 5. BLEEDING TIME IN CHRONIC AVIAN MALARIA.

UNIV. OF MICH.

THE EFFECT ON CULEX LARVÆ OF PARIS GREEN DILUTED WITH CHARCOAL AND NOTES ON THE FEEDING HABITS OF CULEX QUINQUEFASCIATUS LARVICIDE STUDIES, V[1]

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and

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THREE PLATES AND ONE TEXT FIGURE

In previous articles[2] charcoal was suggested as a diluent and partial adsorbent for Paris green mixtures prepared in the usual way for the destruction of anopheles larvæ. In this paper experiments are reported which indicate that under certain conditions the usefulness of Paris green-charcoal mixtures is not limited to the destruction of anopheles larvæ. We find that this mixture has a markedly lethal effect on culex larvæ, as well.

It has been commonly stated that one of the chief disadvantages of Paris green as a larvicide is the fact that, as ordinarily applied, it leaves the culicine larvæ unaffected.[3] This failure to kill culicine larvæ has been a serious drawback to the use of Paris green not only because certain of the culicines are disease carriers but also because laymen never differentiate in a practical way the two genera *Anopheles* and *Culex*.

---

[1] These studies were undertaken by the Bureau of Science, divisions of organic chemistry and of malaria investigations. The latter is coöperatively supported by the Bureau and by the International Health Division of the Rockefeller Foundation. Mrs. I. Ramos and Miss Victoria Masilungan, microscopists of malaria investigations, assisted in these experiments.

[2] Russell, P. F., and A. P. West, Philip. Journ. Sci. 49 (1932) 211.

[3] Barber, M. A., and T. G. Hayne, U. S. Pub. Health Rep. 36 (1921) 8; Hardenburg, W. E., Mosquito Eradication (1922) 163; Covell, Gordon, Malaria Control by Anti-Mosquito Measures (1931) 70.

A campaign to control malaria by attacking only the anopheles larvæ may become discredited by the public concerned before its effect is realized because culex mosquitoes continue to be prevalent and annoying.

In explanation of the failure of Paris green to kill culex larvæ it is usually stated that Culex larvæ are not surface feeders as are the anophelines and consequently are not able to ingest the floating particles of the larvicide. Griffitts [4] experimented with a mixture of 1 part Paris green and 100 parts of moist sand. This diluent carried a high proportion of the Paris green to the bottom of the pond where it was used. Some Paris green was left on the surface of the water, either floating free or adherent to floating particles of sand. He found in a series of experiments that Paris green applied in this manner is lethal to culex and aëdes mosquitoes. He concluded, "now that it has been determined that these sub-surface-feeding larvæ are highly susceptible to the toxic action of Paris green, it remains to determine the best methods of applying this mixture to the areas requiring treatment."

It should also be noted that Williams and Cook [5] in a series of experiments, in which Paris green diluted with powdered soapstone was spread by airplane, killed a high percentage of culex larvæ in their first three experiments. Subsequently, Paris green had little or no effect on culex larvæ.

EXPERIMENTAL PROCEDURE

The mixture used in these experiments was made with 1 part Paris green and 99 parts of powdered wood charcoal. The charcoal floated easily upon the surface of water. Certain kinds of charcoal do not float so well and are not suitable for experiments such as these. In the laboratory only third- and fourth-stage larvæ of the species *Culex quinquefasciatus* (*fatigans*) were used and the amount of larvicide spread on the pans was carefully determined. Larvæ were not pronounced dead until all motion had ceased. Control pans, beakers, or jars were always used with the same species of larvæ, the same water, and external influences.

In the pond experiments the dipping was standardized by marking out regular stations around the pond, by making one dip each time in a prescribed way, and by turning back the living catch each time. The larvicidal mixture was applied with a hand bellows (blower) which was weighed with its contents before and after use. The sides and the bottom of the pond (Plate 1) were made of concrete. The measurements of the pond, which bulged out beyond the curve of a circle, were as follows: Length, 4.9 meters; width, 4.83 meters; depth, 0.593 meter; calculated surface area, 20.1 square meters.

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[4] U. S. Pub. Health Rep. 42 (1927) 2701.

[5] U. S. Pub. Health Rep. 42 (1927) 459.

RESULTS

In Table 1 are presented the results of some tests of the larvicidal properties of this charcoal-Paris green mixture using culex larvæ. Laboratory containers of different heights (Plate 2) were used as noted in the table.

It will be seen that there was a well-marked lethal effect on the culex larvæ in each of the experiments, but the quick and complete results seen in the experiments with anopheles larvæ in our first paper[6] were not obtained. It takes more time to kill culex larvæ with Paris-green because, as noted below, their feeding habits are different.

In Table 2 are the results of similar experiments with Paris green but using other vehicles than charcoal. Here the results are not quite so good. Sand mixture does nearly as well as charcoal but lime and rice-stalk ashes as diluents distinctly lower the effectiveness of Paris green.

In Tables 3, 4, and 5 are reported the results of three experiments carried out in the open in a fishpond at the Bureau of Science. This pond was made available by the courtesy of Mr. Wallace Adams, chief of the division of fisheries, Bureau of Science.

Inspection of the tables will show that, in a pond of still water, Paris-green and charcoal mixture blown on the surface is an effective larvicide against culex mosquitoes. It is slower to act, however, than against anopheles larvæ and not quite so effective.

In the first experiment the larvæ were not completely eradicated but the total catch dropped from 1023 on the 17th to 12 on the 20th. This experiment was discontinued because one pregnant mosquito fish had inadvertently been left in the pond, or had gotten in, and had given birth to a litter of young fish on the morning of the 17th. After this experience not only was the water removed from the pond but also all of the mud at the bottom. The pond was then filled with fresh water for subsequent experiments.

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[6] Philip. Journ. Sci. (in press).

Many dead larvæ were found on the mornings of the 18th, 19th, and 20th. On dissection charcoal and Paris green particles were found in the gut of these larvæ.

In the second and third experiments, as shown in Tables 4, and 5, complete disappearance of the larvæ at the dipping stations was observed. Larvæ were very slow to reappear in the pond after each application of Paris green.

In Table 6 is a record of larvæ which pupated a few hours after the application of the Paris green in the second pond experiment (Table 4). It will be noted that most of these larvæ subsequently emerged as adults. In other words the charcoal-Paris green mixture did not act quickly enough to harm them.

DISCUSSION

It is clear that arsenic is not only lethal to anopheles larvæ but also to culex. This has been demonstrated by Griffitts[7] and by the experiments reported in this paper. The question is how the larvæ ingest the Paris green.

In order to kill culex larvæ with Paris green, it must be made available to them. Griffitts accomplished this by sinking the Paris green with moist sand. We have had good results, as shown above, by mixing charcoal with Paris green. The charcoal floats indefinitely and the Paris green is supported by the charcoal. The culex larvæ have sufficient time to ingest a lethal dose. With anopheles larvæ the period required to ingest a lethal dose of Paris green floating on the surface is measured in minutes, with culex larvæ it is measured in hours. Therefore, a charcoal and Paris green mixture applied on running water in ditches would probably have considerably less effect on culex larvæ than it has had in a still-water pond in our experiments. For water standing in fire buckets, still ponds, and similar places it would seem that Paris green-charcoal mixtures would be very useful as a culex larvicide.

Another point to notice, as brought out in Tables 3, 4, and 5, is that the persistent floating properties of the charcoal result in a film which lasts for days instead of hours. This film appears to act as a deterrent. It also keeps the Paris green available for the larvæ which hatch subsequently or which at the time of application are too small to ingest the larvicide.

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[7] U. S. Pub. Health Rep. 42 (1927) 2701.

It is not the purpose of this paper to recommend Paris green as the larvicide of choice for culex mosquitoes; but to point out that in an antimalaria attack on anopheles mosquito larvæ, in localities where the carrier breeds in still water, Paris green used with charcoal will kill not only all of the anopheles larvæ but also most and sometimes all of the culex larvæ as well.

FEEDING HABITS OF CULEX QUINQUEFASCIATUS LARVÆ

In Tables 7 and 8 are the results of some observations made to determine something of the feeding habits of culex larvæ. An investigation of these habits reveals that culex larvæ are more versatile than anopheles larvæ. Culex larvæ feed at the surface, below the surface, and at the bottom. In a group of culex larvæ, at a given time, under the same conditions, and in the same laboratory pan or outdoor breeding place, some will be found feeding at the surface, some at the bottom, and a larger number just beneath the surface hanging head down as in the classical illustrations.

In Table 7, are given the results of fifty-two observations on the feeding habits of the larvæ of *Culex quinquefasciatus.* As shown by the data an average of 12 per cent of the larvæ were feeding at the bottom of the pan, 15 per cent at the surface, and 73 per cent in the subsurface position.

If the larvæ are placed in a jar in which the depth of the water is relatively great (56.7 centimeters) very few, if any, larvæ will be found at the bottom. The results of sixty observations (Table 8) show that an average of about 21 per cent of the larvæ were feeding at the surface. An average of about 69 per cent were feeding in the usual subsurface position, and only two larvæ were seen at the bottom. An average of about 11 per cent were in a deep subsurface position. These larvæ were not feeding but exploring about 15 centimeters below the water surface.

It is necessary to be careful in referring to culex larvæ to make it plain that they do not feed constantly in one position relative to the surface of the water. Depth of water and conditions of food supply have, of course, a definite influence.

Text fig. 1, drawn from life, illustrates the position of culex larvæ when feeding at the surface. By a relatively powerful action of abdominal muscles the head is raised to the surface,

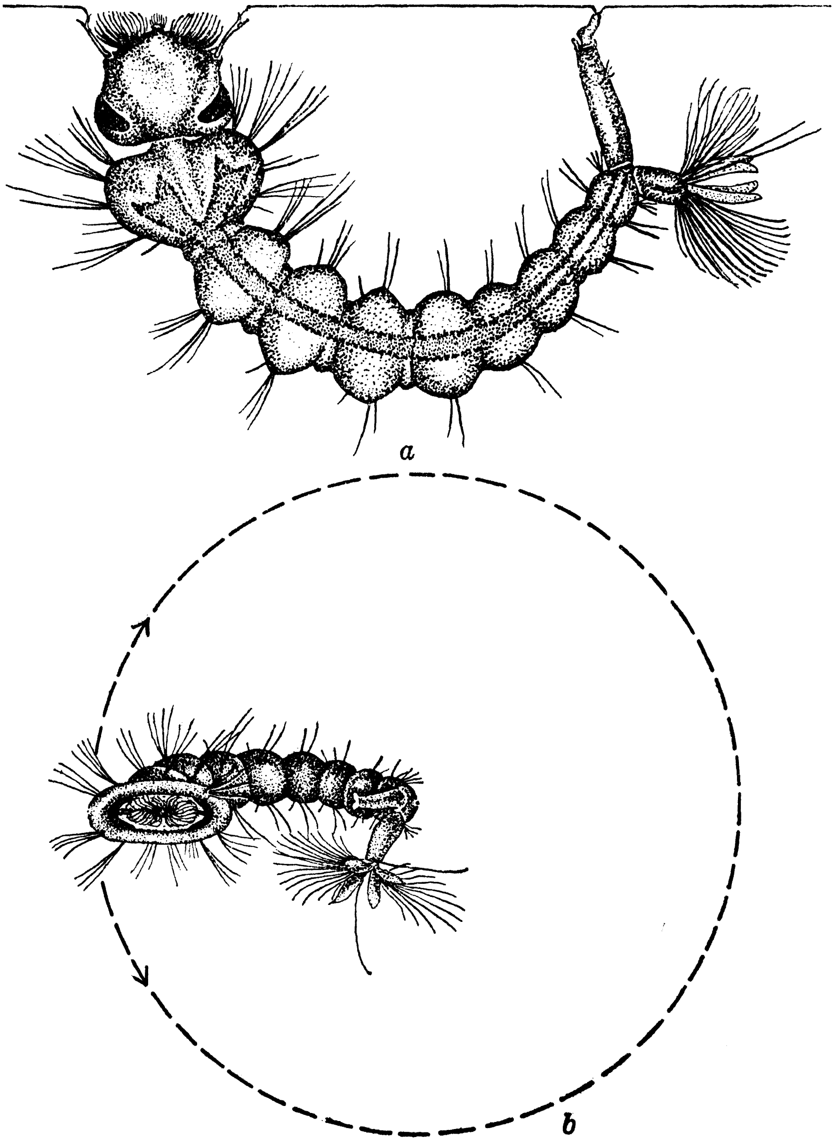


FIG. 1. *Culex quinquefasciatus; a,* position when feeding at the surface; *b,* pivoting maneuver when feeding at the surface. (Drawn from life, by L. Moskaira.)

the body of the larva being bent like a bow. With the siphon as a fixed pivot the larva swings around and around, now clockwise and now counter clockwise, using the mouth parts and brushes to accomplish this unique feeding maneuver. This has been observed time and again in these experiments.

Plate 3 shows photographs of intestinal tracts dissected from *Culex quinquefasciatus* larvæ after feeding on charcoal and Paris green mixture floating on the surface of water in a pan. The charcoal observed in the intestinal tract shows that the culex larvæ actually ingest material which floats on the surface of water and that this material passes into and fills the intestinal tract.

In view of these observations it is not strange that Paris green, if kept afloat long enough, will kill culex larvæ. So too, when carried to the bottom, Paris green is also available to culex larvæ if the water is shallow, but the feeding time at the surface is greater than at the bottom. Moreover, at the surface both culex and anopheles larvæ take the Paris green mixture.

SUMMARY

Charcoal mixed with Paris green, 99 parts to 1, has been shown to be an effective larvicide against culex mosquitoes in laboratory containers and in a pond where the water was not moving.

An investigation of the feeding habits of *Culex quinquefasciatus* shows that these larvæ feed at the surface, below the surface, and at the bottom of shallow water.

Paris green, if supported by charcoal and kept afloat, will not only destroy all anopheles larvæ but will kill a high percentage of *Culex quinquefasciatus* larvæ as well.

TABLE 1.—*Larvicidal effect of Paris green-charcoal mixture (1 to 100) on Culex quinquefasciatus larvæ. Experiments made in laboratory containers.*

[In each experiment there were used 50 larvæ of third and fourth stage.]

Test No.	Type of container.	Depth of water.	Area of water surface.	Weight of larvicide.	Percentage of dead larvæ. Cumulative totals in time periods (hours).									Pupæ.
					1	2	3	4	5	6	24	48	72	
		cm.	*sq. cm.*	*g.*										
1	Pan	3.0	600.0	0.1	0	0	2	8	18	24	86	98	100	0
2	do	3.0	600.0	0.1	0	2	4	4	20	34	84	96	100	1
3	do	3.0	600.0	(a)	0	0	0	0	0	0	2	6	10	4
4	do	3.0	600.0	(a)	0	2	2	6	6	6	10	10	10	1
5	Beaker	21.6	254.5	0.1	0	0	2	10	14	38	78	86	88	4
6	do	21.6	254.5	0.1	2	2	16	56	60	72	96	100	100	0
7	do	21.6	254.5	(a)	0	0	0	0	0	0	0	2	6	2
8	Jar	59.0	314.2	0.1	2	4	4	6	12	12	96	96	96	0
9	do	59.0	314.2	0.1	0	0	0	0	--------	--------	92	98	98	0
10	do	59.0	314.2	0.1	0	0	2	2	2	--------	10	74	88	0
11	do	59.0	314.2	0.1	0	0	0	0	--------	--------	80	90	98	0
12	do	59.0	314.2	(a)	0	0	0	0	0	0	0	0	0	8
13	do	59.0	314.2	(a)	0	0	0	0	0	0	0	0	0	17
14	do	59.0	314.2	(a)	0	0	0	0	--------	--------	4	4	4	30

[a] Control test.

TABLE 2.—*Larvicidal effect on Culex quinquefasciatus larvæ of Paris green mixtures (1 to 100) with diluents other than charcoal.*[a]

Test No.	Diluent used.	Percentage of dead larvæ. Cumulative totals in time periods (hours).									Pupæ.
		1	2	3	4	5	6	24	48	72	
1	Sand	0	2	2	2	4	4	40	62	84	0
2	do	0	2	2	2	------	------	66	90	94	1
3	Lime	0	0	8	10	14	------	28	76	76	0
4	do	0	0	2	2	------	------	74	86	88	5
5	do	0	0	2	2	------	------	10	12	52	8
6	do	0	0	0	4	4	6	20	70	76	0
7	Rice-stalk ashes	0	0	0	2	2	------	30	36	58	1
8	do	0	0	0	0	2	6	8	60	72	0
9	do	0	0	0	0	2	8	10	50	64	2
10	Control	0	0	0	0	0	0	0	0	0	13
11	do	0	0	2	2	2	2	2	2	2	9
12	do	0	0	0	0	0	0	0	0	0	1
13	do	0	0	0	0	0	0	2	4	4	1

[a] In each test 50 *Culex quinquefasciatus* larvæ were used. The container was a jar with surface area of 314.2 square centimeters and water depth of 59 centimeters. In each case 0.1 gram of the larvicide mixture was used.

TABLE 3.—*First experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science in 1932.)*[a]

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
FEBRUARY 11, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	3	0	0	0	0	1	6	1	2	3	6	1	4	0	0	0	0	0	27
Stages 3 and 4	27	2	0	0	1	1	74	6	6	3	4	10	7	2	0	1	2	3	149
Pupæ	0	0	0	0	0	0	4	0	0	1	2	0	0	0	0	0	0	0	7
Larvæ and pupæ totals·																			
Living	30	2	0	0	1	2	84	7	8	7	12	11	11	2	0	1	2	3	183
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEBRUARY 12, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	1	0	1	0	0	0	21	8	12	13	37	21	10	20	0	0	0	0	144
Stages 3 and 4	18	23	16	5	8	7	41	40	22	53	199	27	33	36	1	1	0	2	532
Pupæ	2	1	0	0	0	1	15	8	5	10	66	6	8	1	0	0	1	0	124
Larvæ and pupæ totals:																			
Living	21	24	17	5	8	8	77	56	39	76	302	54	51	57	1	1	1	2	800
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEBRUARY 13, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	258	12	22	36	25	16	65	39	41	46	444	82	35	132	2	8	0	1	1,264
Stages 3 and 4	72	16	8	76	32	13	25	17	15	26	52	17	41	34	2	1	3	0	450
Pupæ	3	0	0	8	12	5	9	0	1	0	20	0	0	5	1	2	0	0	66
Larvæ and pupæ totals:																			
Living	333	28	30	120	69	34	99	56	57	72	516	99	76	171	5	11	3	1	1,780
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FEBRUARY 14, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	226	59	49	51	28	34	45	25	24	17	200	67	25	25	7	3	1	6	892
Stages 3 and 4	40	18	13	9	10	21	8	28	20	36	42	18	14	6	5	10	4	3	305
Pupæ	10	2	5	9	0	9	21	3	1	6	0	7	5	2	1	3	0	0	84
Larvæ and pupæ totals:																			
Living	276	79	67	69	38	64	74	56	45	59	242	92	44	33	13	16	5	9	1,281
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEBRUARY 15, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	162	37	41	42	70	112	105	4	18	20	99	20	0	4	2	7	6	3	752
Stages 3 and 4	75	28	17	10	82	145	29	16	22	24	109	9	15	5	2	7	8	4	607
Pupæ	6	15	5	0	4	3	5	3	10	16	7	1	0	0	0	5	7	2	89
Larvæ and pupæ totals:																			
Living	243	80	63	52	156	260	139	23	50	60	215	30	15	9	4	19	21	9	1,448
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEBRUARY 16, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	20	14	24	19	16	12	134	10	9	23	97	12	30	11	3	11	4	1	450
Stages 3 and 4	34	10	14	19	29	19	24	6	13	13	132	13	12	12	13	15	4	4	386
Pupæ	6	3	7	14	7	3	1	1	0	4	13	4	3	2	15	5	3	6	97
Larvæ and pupæ totals:																			
Living	60	27	45	52	52	34	159	17	22	40	242	29	45	25	31	31	11	11	933
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEBRUARY 17, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	21	11	8	29	16	24	17	74	8	26	13	14	12	17	9	4	49	12	364
Stages 3 and 4	23	28	11	202	6	17	12	70	20	23	41	10	11	16	13	7	34	13	557
Pupæ	3	5	2	30	14	5	2	2	4	4	2	8	6	0	2	0	8	5	102
Larvæ and pupæ totals:																			
Living	47	44	21	261	36	46	31	146	32	53	56	32	29	33	24	11	91	30	1,023
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] February 10, 1932, 1 p. m., there were placed in the pond 1,515 larvæ of third and fourth stage. February 11, 1932, 2.30 p. m., 9,500 third- and fourth-stage larvæ were also added. February 17, 1932, 10 a. m., 207.9 grams of Paris green-charcoal mixture (1 to 100) were blown over the pond with a hand bellows. February 29, 1932, 9 a. m., the charcoal was still floating evenly on the surface of the water. Some mosquito fish were noticed in the pool.

TABLE 3.—*First experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science in 1932.)*[a]—Continued.

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
FEBRUARY 18, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	0	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	6
Stages 3 and 4	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2
Pupæ	4	2	0	0	3	1	1	1	0	0	0	0	1	0	1	5	0	2	21
Larvæ and pupæ totals:																			
Living	4	3	1	1	3	1	2	2	0	0	1	0	2	0	1	5	0	3	29
Dead	5	2	4	6	7	8	4	4	8	7	6	5	5	6	7	8	7	6	105
FEBRUARY 19, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	1	0	0	1	1	2	2	0	2	2	1	0	0	0	0	0	0	0	12
Stages 3 and 4	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	5
Pupæ	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2
Larvæ and pupæ totals:																			
Living	1	0	1	2	1	3	2	0	2	2	1	1	0	1	1	1	0	0	19
Dead	0	1	1	4	0	1	0	4	2	4	0	5	1	4	0	1	1	3	32
FEBRUARY 20, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	2	0	0	1	1	0	0	1	1	0	0	6
Stages 3 and 4	0	0	0	0	0	0	2	0	0	0	2	0	0	1	0	0	0	1	6
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	0	0	0	0	0	2	2	0	0	3	1	0	1	1	1	0	1	12
Dead	0	0	1	0	2	1	0	0	0	0	1	0	0	1	0	0	0	1	7

[a] February 10, 1932, 1 p. m., there were placed in the pond 1,515 larvæ of third and fourth stage. February 11, 1932, 2.30 p. m., 9,500 third- and fourth-stage larvæ were also added. February 17, 1932, 10 a. m., 207.9 grams of Paris green-charcoal mixture (1 to 100) were blown over the pond with a hand bellows. February 29, 1932, 9 a. m., the charcoal was still floating evenly on the surface of the water. Some mosquito fish were noticed in the pool.

TABLE 4.—*Second experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science.)*[a]

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
MARCH 3, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	6	2	1	1	0	0	0	0	1	0	4	0	0	2	0	1	0	0	18
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	6	2	1	1	0	0	0	0	1	0	4	0	0	2	0	1	0	0	18
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 4, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	3	3	2	1	2	1	20	4	0	3	2	1	2	4	1	1	0	0	50
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	3	3	2	1	2	1	20	4	0	3	2	1	2	4	1	1	0	0	50
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] The experiment was started February 28, 1932, 9 a. m. On that date and February 29, March 1, and March 2 there were no larvæ or pupæ in the pool as determined by tests made those dates at all the catching stations around the pool. March 5, 9.30 a. m., 3,000 third and fourth-stage larvæ were placed in the pool. March 8, 4.15 p. m., 3,440 third and fourth-stage larvæ were also placed in the pool. March 9, 9.30 a. m., 90.4 grams of Paris green-charcoal mixture (1 to 100) were sprayed over the pool with a hand blower.

The day was hot with the sun shining brightly and the wind calm. The Paris green mixture spread nicely over the surface of the water. March 12 the Paris green mixture was only very thinly spread on the surface of the pond. The following days the mixture gradually disappeared until March 17 only a very small amount of Paris green remained.

TABLE 4.—*Second experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science.)*[a]—Continued.

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
MARCH 5, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	13	3	5	6	1	4	79	2	1	4	5	0	2	1	0	0	0	1	127
Stages 3 and 4	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	4
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	13	3	5	6	2	4	79	2	1	5	5	0	2	1	1	0	1	1	131
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 6, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	15	6	3	4	4	4	74	4	2	1	6	2	2	4	1	1	0	0	133
Stages 3 and 4	6	0	4	0	2	0	26	2	4	6	23	2	0	0	0	2	1	1	79
Pupæ	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2
Larvæ and pupæ totals:																			
Living	21	6	7	4	6	4	101	6	6	7	29	5	2	4	1	3	1	1	214
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 7, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	88	18	17	30	136	3	53	15	2	2	5	10	7	3	0	0	2	4	395
Stages 3 and 4	18	14	8	5	32	4	27	3	4	2	5	2	2	5	1	1	3	2	138
Pupæ	0	0	0	0	2	0	2	0	1	0	1	0	0	0	1	0	0	0	7
Larvæ and pupæ totals:																			
Living	106	32	25	35	170	7	82	18	7	4	11	12	9	8	2	1	5	6	540
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 8, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	19	16	3	25	53	35	121	23	57	7	14	3	15	43	0	5	0	1	440
Stages 3 and 4	2	2	2	9	8	13	6	1	4	3	1	27	2	1	0	0	1	0	82

Pupæ	2	0	1	1	1	3	2	3	1	1	1	0	2	0	1	1	1	1	22
Larvæ and pupæ totals:																			
Living	23	18	6	35	62	51	129	27	62	11	16	30	19	44	1	6	2	2	544
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 9, 9 A. M.																			
Larvæ:																			
Stages 1 and 2	14	11	34	11	18	23	17	9	13	13	17	2	4	18	6	2	0	4	216
Stages 3 and 4	37	12	19	15	42	63	61	14	6	32	137	26	8	9	3	4	5	6	499
Pupæ	5	0	2	2	3	7	30	0	3	4	58	3	4	3	0	0	2	0	126
Larvæ and pupæ totals:																			
Living	56	23	55	28	63	93	108	23	22	49	212	31	16	30	9	6	7	10	841
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 9, 3.30 P. M.																			
Larvæ:																			
Stages 1 and 2	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
Stages 3 and 4	2	0	3	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	8
Pupæ	8	0	0	0	0	2	35	2	0	0	3	0	0	2	0	1	1	1	55
Larvæ and pupæ totals:																			
Living	11	0	3	2	0	2	36	2	1	1	3	0	0	2	0	1	1	2	67
Dead	4	2	4	2	2	2	0	2	0	2	2	1	1	4	4	0	0	2	34
MARCH 10, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Stages 3 and 4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Pupæ	6	0	1	0	1	0	6	0	1	1	7	5	1	4	0	0	1	0	34
Larvæ and pupæ totals:																			
Living	6	0	1	0	1	0	6	0	2	1	7	5	1	4	1	0	1	0	36
Dead	2	1	2	1	2	0	2	2	0	1	0	1	1	0	1	0	0	2	18

[a] The experiment was started February 28, 1932, 9 a. m. On that date and February 29, March 1, and March 2 there were no larvæ or pupæ in the pool as determined by tests made those dates at all the catching stations around the pool. March 5, 9.30 a. m., 3,000 third and fourth-stage larvæ were placed in the pool. March 8, 4.15 p. m., 3,440 third and fourth-stage larvæ were also placed in the pool. March 9, 9.30 a. m., 90.4 grams of Paris green-charcoal mixture (1 to 100) were sprayed over the pool with a hand blower.

The day was hot with the sun shining brightly and the wind calm. The Paris green mixture spread nicely over the surface of the water. March 12 the Paris green mixture was only very thinly spread on the surface of the pond. The following days the mixture gradually disappeared until March 17 only a very small amount of Paris green remained.

TABLE 4.—*Second experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science.)*[a]—Continued.

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
MARCH 11, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dead	1	2	1	0	1	0	2	0	0	0	1	0	1	0	1	0	0	0	10
MARCH 12, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	4
Dead	1	0	1	0	0	0	0	1	0	1	1	1	1	0	1	0	1	0	9
MARCH 13, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	1	2	1	0	0	3	9	1	0	1	1	3	1	0	0	0	0	0	23
Stages 3 and 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	2	2	1	0	0	3	9	1	0	1	1	3	1	0	0	0	0	0	24
Dead	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
MARCH 14, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	4	1	1	1	1	1	5	1	2	1	3	0	1	2	0	1	0	0	25
Stages 3 and 4	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	0	0	0	5

Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	4	1	1	1	1	2	6	1	2	2	3	1	1	3	0	1	0	0	30
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 15, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	2	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	6
Stages 3 and 4	2	1	1	1	1	3	9	1	0	0	2	1	0	1	1	0	0	0	24
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	2	3	1	4	1	3	9	1	1	0	2	1	0	1	1	0	0	0	30
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 16, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Stages 3 and 4	5	1	2	1	1	1	1	2	1	1	4	1	1	1	1	0	0	0	24
Pupæ	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Larvæ and pupæ totals:																			
Living	6	1	2	1	1	1	1	2	1	1	5	1	1	1	1	0	0	0	26
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 17, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	1	2	0	2	1	4	4	0	1	1	1	1	0	1	0	0	1	0	20
Pupæ	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Larvæ and pupæ totals:																			
Living	1	2	0	2	1	4	5	0	1	1	1	1	0	1	0	0	1	0	21
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] The experiment was started February 28, 1932, 9 a. m. On that date and February 29, March 1, and March 2 there were no larvæ or pupæ in the pool as determined by tests made those dates at all the catching stations around the pool. March 5, 9.30 a. m., 3,000 third and fourth-stage larvæ were placed in the pool. March 8, 4.15 p. m., 3,440 third and fourth-stage larvæ were also placed in the pool. March 9, 9.30 a. m., 90.4 grams of Paris green-charcoal mixture (1 to 100) were sprayed over the pool with a hand blower.

The day was hot with the sun shining brightly and the wind calm. The Paris green mixture spread nicely over the surface of the water. March 12 the Paris green mixture was only very thinly spread on the surface of the pond. The following days the mixture gradually disappeared until March 17 only a very small amount of Paris green remained.

TABLE 5.—*Third experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science.)*[a]

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
MARCH 18, 9.30 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Stages 3 and 4	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Pupæ	0	0	0	1	1	1	2	1	1	0	1	0	0	0	1	0	1	0	10
Larvæ and pupæ totals:																			
Living	0	0	1	2	1	1	2	1	2	0	1	0	0	0	1	0	1	0	13
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
MARCH 22, 8 A. M.																			
Larvæ:																			
Stages 1 and 2	22	0	5	2	4	6	0	3	4	7	36	10	8	4	2	1	1	1	116
Stages 3 and 4	34	2	1	1	0	1	5	4	7	18	89	12	9	4	2	1	0	1	191
Pupæ	6	0	0	0	2	0	2	0	1	0	2	1	0	0	0	0	0	0	14
Larvæ and pupæ totals:																			
Living	62	2	6	3	6	7	7	7	12	25	127	23	17	8	4	2	1	2	321
Dead	1	1	0	1	0	0	0	0	0	3	1	1	1	1	0	1	0	1	12
MARCH 22, 3.50 P. M.																			
Larvæ:																			
Stages 1 and 2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Stages 3 and 4	4	1	3	0	0	0	0	1	1	0	4	2	0	0	1	0	2	1	20
Pupæ	3	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	7
Larvæ and pupæ totals:																			
Living	9	1	3	0	0	0	0	1	1	0	6	2	0	0	1	0	4	1	29
Dead	3	1	0	4	2	1	3	2	1	0	2	4	4	1	2	3	1	1	35

MARCH 23, 8 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	1	0	0	0	0	0	1	1	1	0	3	1	3	0	0	0	0	0	11
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	1	0	0	0	0	0	1	1	1	0	3	1	3	0	0	0	0	0	11
Dead	2	3	1	2	1	4	1	2	6	1	4	0	4	2	4	5	3	2	47
MARCH 24, 8 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dead	0	1	0	0	0	0	0	1	1	0	0	0	0	0	2	3	0	1	9
MARCH 29, 8 A. M.																			
Larvæ:																			
Stages 1 and 2	0	1	0	0	0	0	0	1	2	1	1	1	0	0	0	0	0	0	7
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	1	0	0	0	0	0	1	2	1	1	1	0	0	0	0	0	0	7
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] March 18, 1932, the Paris green mixture from the last experiment had almost disappeared and the following day there was practically none left. However, there were dust and leaves on the surface of the pond. March 19 and 21, 9.30 a. m., tests were made at all the catching stations. March 19, only one pupa was found (station 14). March 21 only one larva of the third and fourth stage was found (station 16). The surface of the pond was cleared of leaves and approximately 11,000 larvæ were added. March 22, 9.30 a. m., there were sprayed over the pond 80.69 grams of Paris green mixture. March 22, 3 p. m., some dead larvæ were taken from the pond and dissected. Particles of Paris green were found but the color had changed from bluish green to light green. March 23, 8 a. m., and March 24, 8 a. m., there was still plenty of Paris green on the surface of the pond but one living larva was found near the side of the pond. March 26, 8 a. m., the Paris green mixture was only thinly spread on the surface of the pond and no larvæ were found. The following day Paris green had disappeared and still no larvæ were found. March 29, 8 a. m., a few small larvæ were noticed along the sides of the pond. The following day the water was very clear and again a few small larvæ were found. These were *Anopheles subpictus* (var. *indefinitus*) and were taken at stations 8, 12, and 17. March 31, 8 a. m., a few small larvæ of *Anopheles subpictus* (var. *indefinitus*) were found in dips taken at station 10.

TABLE 5.—*Third experiment with Paris green-charcoal mixture (1 to 100) as larvicide for culex larvæ. (Experiment carried out in a pond at the Bureau of Science.)*[a]—Continued.

Date and stages of larvæ and pupæ.	Catching stations.																		Total.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
MARCH 30, 8 A. M.																			
Larvæ:																			
Stages 1 and 2	0	2	0	1	0	0	1	1	0	0	0	2	0	0	0	0	1	0	8
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	2	0	1	0	0	1	1	0	0	0	2	0	0	0	0	1	0	8
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARCH 31, 8 A. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	4
Pupæ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larvæ and pupæ totals:																			
Living	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	4
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APRIL 1, 4 P. M.																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3
Larvæ and pupæ totals:																			
Living	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APRIL 2																			
Larvæ:																			
Stages 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stages 3 and 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupæ	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
Larvæ and pupæ totals:																			
Living	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
Dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] March 18, 1932, the Paris green mixture from the last experiment had almost disappeared and the following day there was practically none left. However, there were dust and leaves on the surface of the pond. March 19 and 21, 9.30 a. m., tests were made at all the catching stations. March 19, only one pupa was found (station 14). March 21 only one larva of the third and fourth stage was found (station 16). The surface of the pond was cleared of leaves and approximately 11,000 larvæ were added. March 22, 9.30 a. m., there were sprayed over the pond 80.69 grams of Paris green mixture. March 22, 3, p. m., some dead larvæ were taken from the pond and dissected. Particles of Paris green were found but the color had changed from bluish green to light green. March 23, 8 a. m., and March 24, 8 a. m., there was still plenty of Paris green on the surface of the pond but one living larva was found near the side of the pond. March 26, 8 a. m., the Paris green mixture was only thinly spread on the surface of the pond and no larvæ were found. The following day Paris green had disappeared and still no larvæ were found. March 29, 8 a. m., a few small larvæ were noticed along the sides of the pond. The following day the water was very clear and again a few small larvæ were found. There were *Anopheles subpictus* (var. *indefinitus*) and were taken at stations 8, 12, and 17. March 31, 8 a. m., a few small larvæ of *Anopheles subpictus* (var. *indefinitus*) were found in dips taken at station 10.

TABLE 6.—*Emergence record of larvæ which pupated soon after the application of charcoal-Paris green mixture on the Bureau of Science pond. (See also Table 4.)*

Date and hour.	Pupæ collected in the pond.	Emerged mosquitoes.		Dead female mosquitoes.[a]	Dead pupæ.
		Male.	Female.		
March 9, 1932, 4 p. m	85	--------	--------	--------	--------
March 10, 1932, 7.45 a. m	--------	7	10	--------	--------
March 11, 1932, 10 a. m	--------	32	29	1	6

[a] No dead male mosquitoes were found.

TABLE 7.—*Feeding positions of Culex quinquefasciatus larvæ.*

Date and hour observed.	Larvæ feeding.[a]		
	At surface.	Sub-surface.	At bottom.
	Per cent.	*Per cent.*	*Per cent.*
MARCH 31, 1932			
a. m.			
11.15	9	65	26
11.20	12	76	12
11.25	12	84	4
11.30	14	67	19
p. m.			
1.55	8	78	14
2.00	16	67	17
2.05	14	72	14
2.10	9	74	17
2.15	10	78	12
2.20	17	81	2
2.25	10	72	18
2.30	13	71	16
2.35	11	61	28
2.40	12	68	20
2.45	13	66	21
2.50	8	63	29
2.55	11	76	13
3.00	20	72	8
3.05	21	67	12
3.10	18	70	12
3.15	19	69	12
3.20	18	69	13
3.25	12	67	21
3.30	15	60	25
3.35	12	65	23
3.40	20	59	21
3.45	18	64	18
p. m.			
3.50	18	70	12
APRIL 6, 1932			
a. m.			
8.35	13	78	9
8.45	10	83	7
8.50	11	86	3
8.55	11	82	7
9.00	12	83	5
9.05	16	73	11
9.10	13	76	11
9.15	18	74	8
9.20	13	85	2
9.25	18	73	9
9.30	16	81	3
9.35	15	79	6
9.40	21	72	7
9.45	26	69	5
9.50	12	75	13
9.55	16	71	13
10.00	18	79	3
10.05	15	78	7
10.10	16	73	11
10.15	16	81	3
10.20	17	77	6
10.25	23	74	3
10.30	23	70	7
10.35	24	68	8
Average	15	73	12

[a] There were 100 larvæ at all times in the pan which had a surface area of 600 square centimeters and a water depth of 3 centimeters.

TABLE 8.—*Feeding position of Culex quinquefasciatus larvæ.*[a]

Date and hour observed.	Larvæ feeding.			
	At surface.	At subsurface.	Deep subsurface.	At bottom.
APRIL 6, 1932				
p. m.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
12.15	12	78	10	0
12.20	7	69	24	0
12.25	18	76	6	0
12.30	17	80	3	0
12.35	11	78	9	2
12.40	9	91	0	0
12.45	14	77	9	0
12.50	15	77	8	0
12.55	19	73	8	0
1.00	16	76	8	0
APRIL 7, 1932				
a. m.				
8.30	36	56	8	0
8.35	34	63	3	0
8.40	38	60	2	0
8.45	36	60	4	0
8.50	31	68	1	0
8.55	12	64	24	0
9.00	19	75	6	0
9.05	20	70	10	0
9.10	27	67	6	0
9.15	22	72	6	0
9.20	22	69	9	0
9.25	20	64	16	0
9.30	26	67	7	0
9.35	28	68	4	0
9.40	21	66	13	0
9.45	22	61	17	0
9.50	26	60	14	0
9.55	27	62	11	0
10.00	26	61	13	0
10.05	22	63	15	0
10.20	33	56	11	0
10.25	25	61	14	0
10.30	20	76	4	0
10.35	23	64	13	0
10.40	19	60	21	0
10.45	28	68	4	0
10.50	24	63	13	0
10.55	26	64	10	0
11.00	21	62	17	0
11.05	24	76	0	0

[a] There were 100 larvæ in the jar at all times. "At surface" means actually feeding from the surface film. "Subsurface" means feeding in the usual culex manner with siphon at water surface and head hanging down. "Deep subsurface" means about 15 centimeters below the surface. Larvæ were not feeding but exploring. Depth of water in the jar was 56.7 centimeters. Area of water surface was 314.16 square centimeters. Diameter of jar was 20 centimeters.

TABLE 8.—*Feeding position of Culex quinquefasciatus larvæ* [a]—Continued.

Date and hour observed.	Larvæ feeding.			
	At surface.	At subsurface.	Deep subsurface.	At bottom.
APRIL 7, 1932				
a. m.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
11.10	26	63	11	0
11.15	20	66	14	0
11.20	22	69	9	0
11.25	28	69	3	0
11.30	22	66	12	0
11.35	28	63	9	0
11.40	15	72	13	0
11.45	21	66	13	0
11.50	18	60	22	0
11.55	23	65	12	0
12.00	17	68	15	0
12.20	9	70	21	0
12.25	8	71	21	0
12.30	10	82	8	0
12.35	12	75	13	0
12.40	11	76	13	0
12.45	10	85	5	0
12.50	16	74	10	0
12.55	9	76	15	0
1.00	11	75	14	0
Average	20.53	68.87	10.57	0.03

[a] There were 100 larvæ in the jar at all times. "At surface" means actually feeding from the surface film. "Subsurface" means feeding in the usual culex manner with siphon at water surface and head hanging down. "Deep subsurface" means about 15 centimeters below the surface. Larvæ were not feeding but exploring. Depth of water in the jar was 56.7 centimeters. Area of water surface was 314.16 square centimeters. Diameter of jar was 20 centimeters.

ILLUSTRATIONS

PLATE 1

Pond at the Bureau of Science where experiments were carried out.

PLATE 2

Type of jars used in experiments showing Paris green-charcoal mixture floating on the surface of the water.

PLATE 3. CULEX QUINQUEFASCIATUS

FIG. 1. Gut of larva after feeding for thirty minutes on a Paris green-charcoal mixture which floated on the surface of the water.

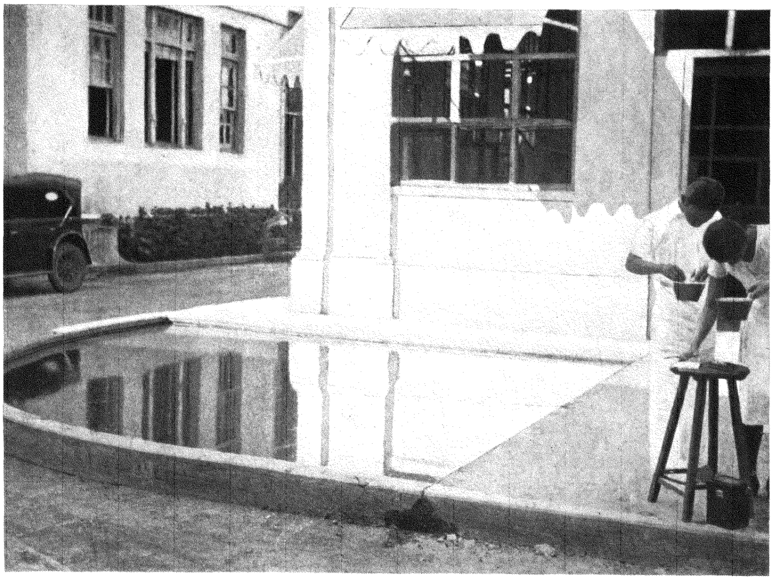
2. Gut of larva after feeding for one hour on a Paris green-charcoal mixture which floated on the surface of the water.

3. Gut of larva after feeding for two hours on a Paris green-charcoal mixture which floated on the surface of the water.

4. Gut of larva after feeding for three hours on a Paris green-charcoal mixture which floated on the surface of the water.

TEXT FIGURE

FIG. 1. *Culex quiquefasciatus; a,* position when feeding at the surface; *b,* pivoting maneuver when feeding at the surface. (Drawn from life by L. Moskaira.)



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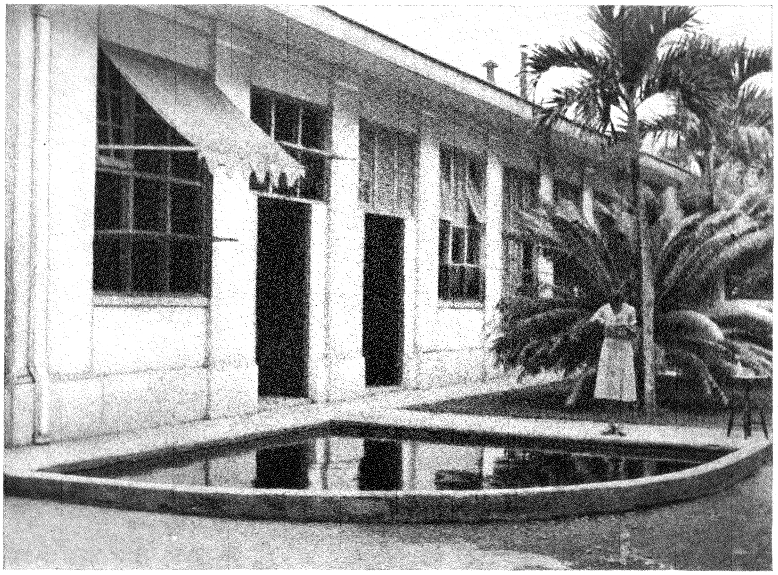

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PLATE 1.

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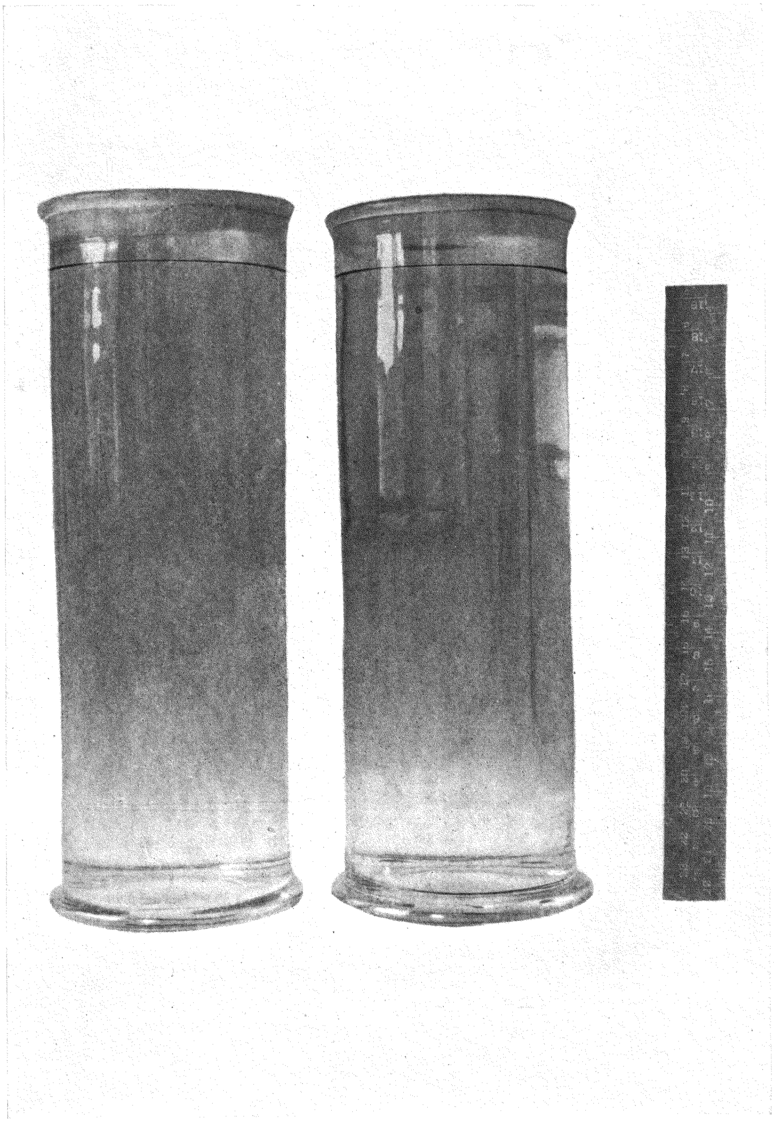

PLATE 2.

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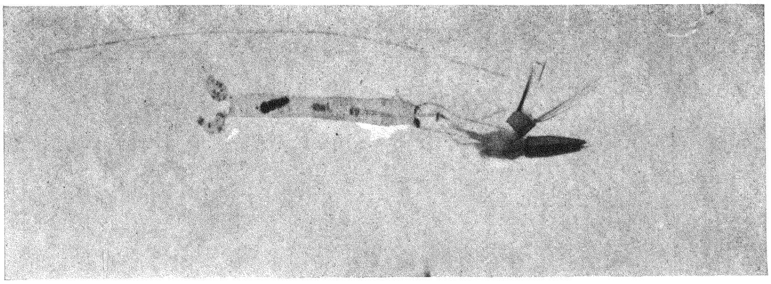

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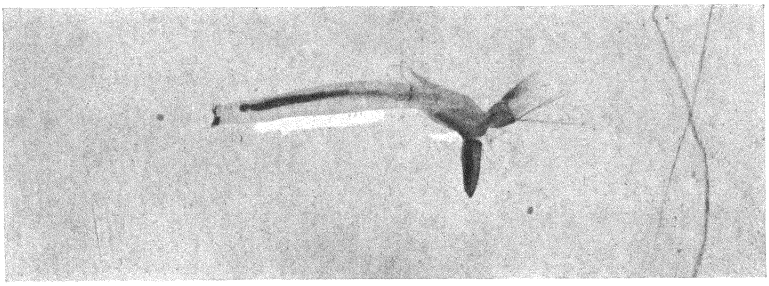

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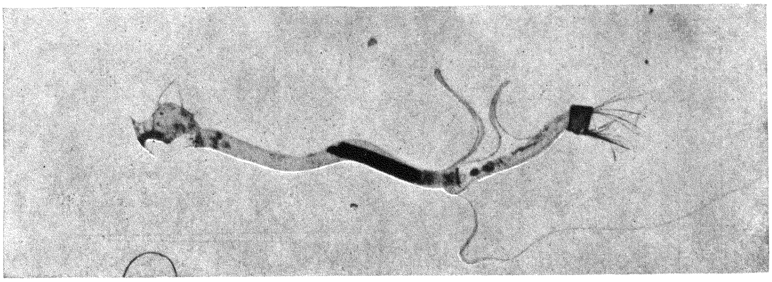

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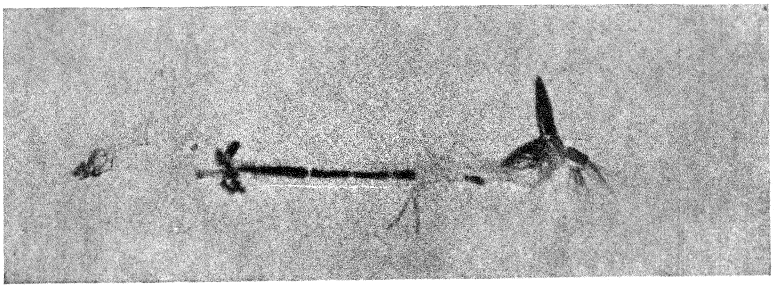

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